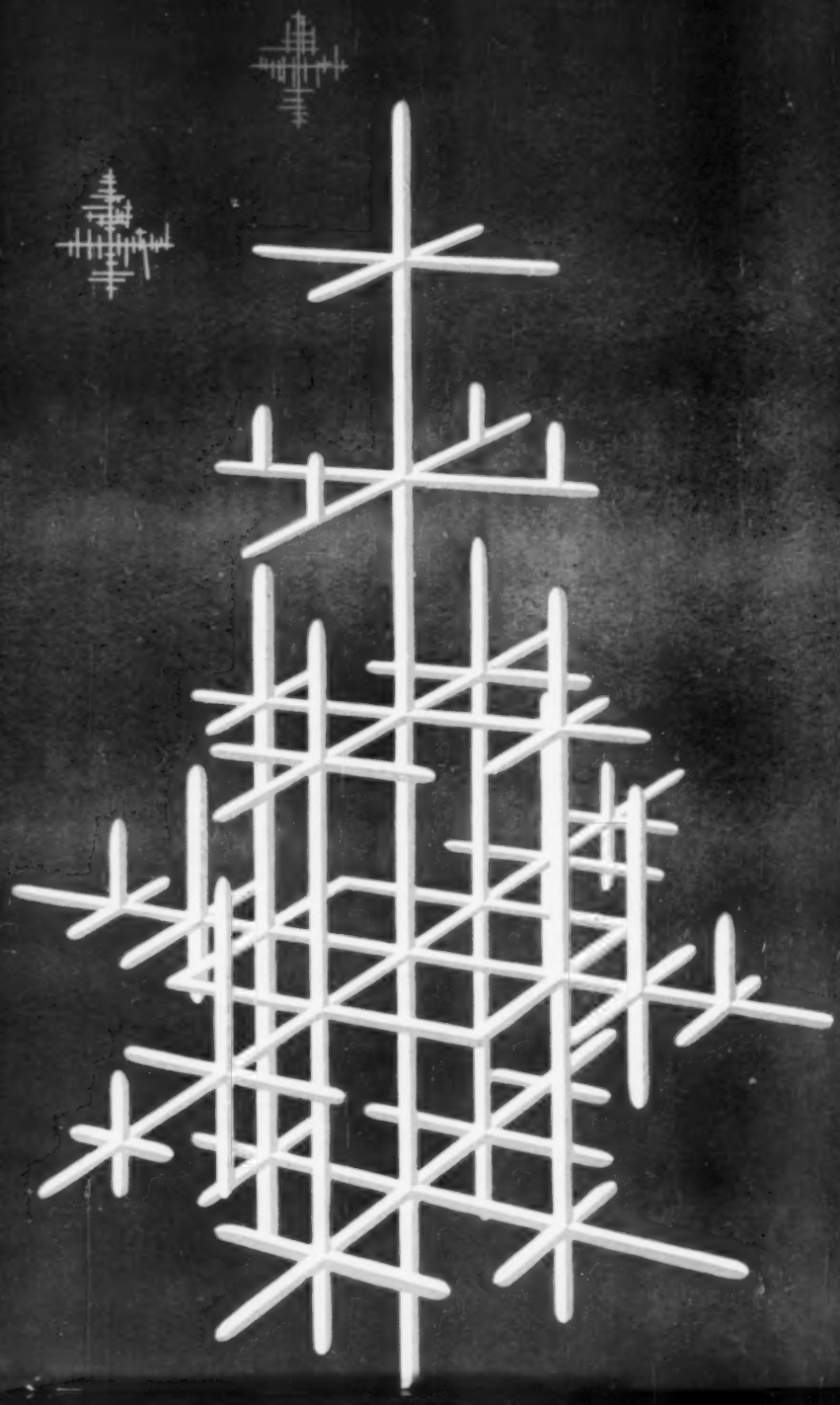
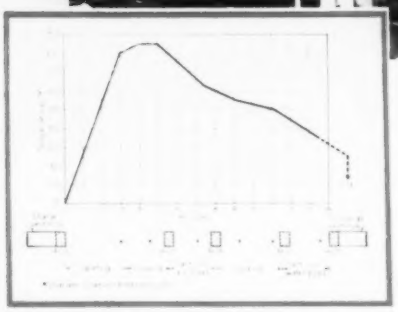
METAL PROGRESS



CYCLE ANNEALING

Hi-Production Scale-Free Annealing in 'Surface' Atmosphere Type, Radiant Tube Heated Furnace.



Typical heating and cooling curve used for cycle annealing, showing zoning of furnace and time that the work stays in each zone.

FOR COMPLETE CYCLE ANNEALING DETAILS—

Write for newly issued bulletin SC-146. Presents operating data on Atmosphere, Radiant Tube and Direct Fired Type Furnaces.

Cycle Annealing is an improved heat treating process for obtaining a good machineable structure consistently on a production basis. It is faster than ordinary annealing and produces parts whose hardness and machinability can be accurately predicted and controlled.

Advantages are:

Savings In Processing Time . . . resulting from fast cooling during portions of the cycle where no transformation is taking place.

Accurate Control Of Metal Structure . . . resulting from close control of temperatures at which transformation takes place.

Reduced Machining Time . . . good machineable metal structure and absence of hard spots allows faster tool speeds.

Reduced Furnace Size . . . possible because of less time in furnace for each part.

Automatic or Semi-Automatic Operation . . . more work processed per operator.

'Surface' atmosphere type, radiant tube fired furnaces and direct fired furnaces are used for the cycle annealing process.

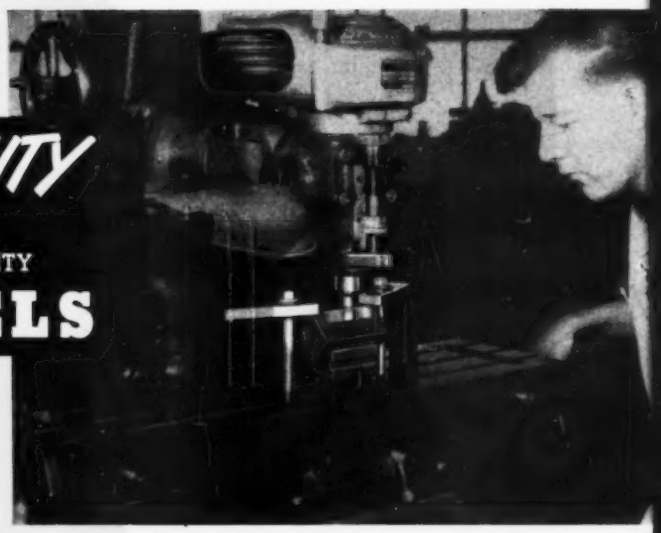
SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging. Gas Atmosphere Generators.

FULL UNIFORMITY

MEANS
IMPROVED MACHINABILITY
IN **DIE STEELS**



Machining Cobalt Chrome Die Steel at Brooke Russell Products.

LATROBE DESEGATIZED*

BRAND

HIGH SPEED STEELS

●

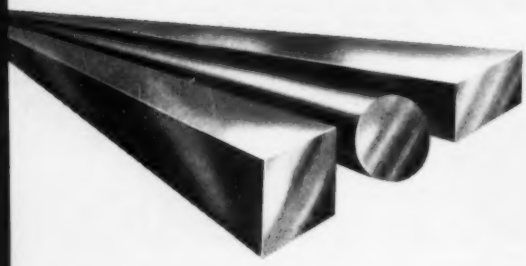
HIGH CARBON–HIGH CHROMIUM DIE STEELS

MACHINABILITY—AN IMPORTANT FACTOR! The full uniformity in Latrobe's Desegatized Brand Steels is a valuable aid to skilled machinists and tool and die makers, and provides experienced craftsmen with a material of superior machinability with which to work. Absence of hard carbide clusters in annealed Desegatized Brand tool steel means easier machining qualities, smoother and more accurate finished surfaces, and the elimination of chattering and tool breakage caused by hard spots in ordinary tool steels.

The uniform cross section of this bar of Latrobe's Desegatized Brand Cobalt Chrome Die Steel means greatly improved machinability with less damage to cutting tools while saving costly cutting time.

Large masses of hard carbide segregates seen in the center of this bar of ordinary die steel cause chattering, rapid tool dulling, and expensive machining time.

*TRADE MARK REGISTERED U. S. PAT. OFFICE



LATROBE ELECTRIC STEEL COMPANY

LATROBE, PENNSYLVANIA

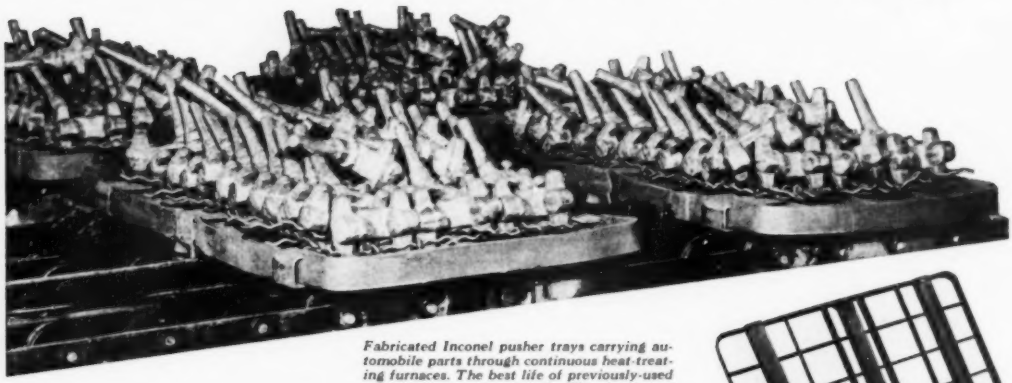
BRANCH OFFICES AND WAREHOUSES LOCATED IN PRINCIPAL CITIES

Write or call your nearest Latrobe Sales Engineer for the complete facts on **LATROBE DESEGATIZED BRAND STEELS**

Metal Progress is published and copyrighted, 1949, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

Meet a *LIGHT-WEIGHT* champion..

Inconel pusher trays still going strong on a job that licked heavier furnace trays!



Fabricated Inconel pusher trays carrying automobile parts through continuous heat-treating furnaces. The best life of previously-used trays averaged nine months. The fabricated Inconel trays have been in use over one year.

- **Furnace production increased**
- **Tray life increased**
- **Maintenance costs reduced**

Inconel pusher tray designed and fabricated by BROWN-HUTCHINSON IRON WORKS, Detroit, Michigan.

These substantial benefits are what a large automobile manufacturer gained by switching to fabricated Inconel* pusher furnace trays.

Previously-used trays weighed from 114 to 198 pounds each. The fabricated Inconel trays weigh only 86 pounds... a weight saving 28 to 112 lbs. per tray. Based on average net load of 400 pounds this represents a gross weight saving of 5 to 19% over previous equipment.

Even more important—these lighter-weight fabricated Inconel trays last longer, with correspondingly reduced replacement and maintenance costs.

This fine performance record is even more remarkable when the severity of service conditions are considered. During the heat-treating of automobile parts, the trays are subjected to temperatures as high as 1650° F., followed by oil quenching.

The furnaces, which are gas-fired and non-atmosphere in type, present high-temperature corrosion problems. Add to these punishing conditions the considerable mechanical forces acting on the trays... up to 540 pounds load plus 2000 pounds thrust from the hydraulic pusher mechanism... *and you have service conditions that demand Inconel plus good fixture design.*

Brown-Hutchinson Iron Works are designers and fabricators of these pusher trays. They, like other leading fabricators, specify Inconel because of Inconel's outstanding performance record and desirable combination of physical characteristics... thermal durability, corrosion-resistance, high hot and cold strength, workability, economy.

For further information about pusher trays made of Inconel, write directly to: Brown-Hutchinson Iron Works, 1831 Clay at G. T. R. R., Detroit, Mich.

*Reg. U. S. Pat. Off.

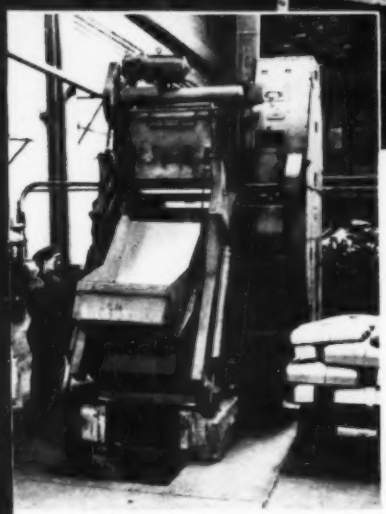
EMBLEM OF SERVICE INCO

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

INCONEL*...for long life at high temperatures

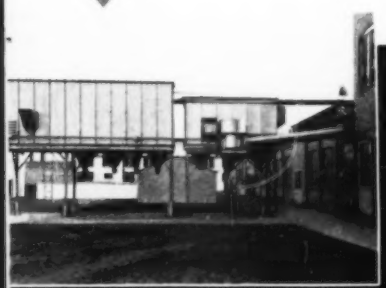
Metal Progress; Page 756

***Type LH ROTOBLAST Table** swiftly cleans large castings for products made by all divisions of Yates-American.*



***7' Type GK ROTOBLAST Barrel** economically cleans small castings for the three Yates-American divisions.*

***CH-2 Pangborn Dust Collector** keeps plant clean, stops dust which shortens life of machines, bearings, etc.*



Pangborn ROTOBLAST* SAVES $5,080

a year for YATES AMERICAN MACHINE CO.

WANT TO CUT CLEANING COSTS?

Here's how Yates-American Machine Co. saves money in their cleaning room:

Their new Pangborn ROTOBLAST team of Barrel and Table cleans small castings *18 times faster* . . . large castings *3.7 times faster* than ever before! *Actual cash savings* add up to $5080 a year on labor alone and two men are released for other work.

Additional savings on machining result from *cleaner castings* . . . and downtime is virtually eliminated! Pangborn ROTOBLAST saves even more . . . replaces five old-fashioned tumbling mills with their dust and dirt. In addition to ROTOBLAST, Yates-American uses equally efficient Pangborn Dust Control to reduce maintenance costs . . . increase worker efficiency by eliminating harmful dust concentrations.

WHAT ROTOBLAST DOES

Pangborn ROTOBLAST *cleans faster* . . . throws more abrasive over large area with greater density. *Cleans better* . . . produces finer surface than old-fashioned methods. *Cleans cheaper* . . . requires less horsepower, less labor, less maintenance, needs no air compressor! *Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment.*

WRITE FOR DETAILS! Find out how much you can save with Pangborn ROTOBLAST. *Write today* for Bulletin 1200 to: PANGBORN CORPORATION, 1404 Pangborn Blvd., Hagerstown, Md.

MORE THAN 25,000 PANGBORN MACHINES SERVING INDUSTRY

Pangborn

* Trademark of Pangborn Corporation

BLAST CLEANS CHEAPER with the right equipment for every job

YOU HAVE THE APPLICATION ...BROWN HAS THE INSTRUMENT!

1. *ElectroniK* Circular Scale Indicator-Controller
2. *ElectroniK* Circular Chart Recorder-Controller
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Your own particular application determines just how precise and just how accurate your temperature control should be . . . and this complete line of instruments gives you the opportunity to pick the control that suits your need.

Your local Honeywell engineer can help you with your selection . . . and he can be impartial about it because he knows that in this line you can find the instrument that is ideal for your operations! Call him in, today . . . or write for catalog.

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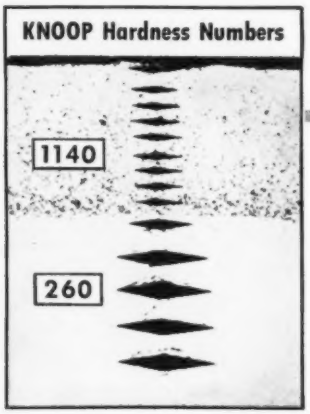
MINNEAPOLIS **Honeywell** *Advanced Instrumentation* FOR METAL PROCESSING — BROWN INSTRUMENTS

TUKON

THE LATEST WORD IN MICROHARDNESS TESTING



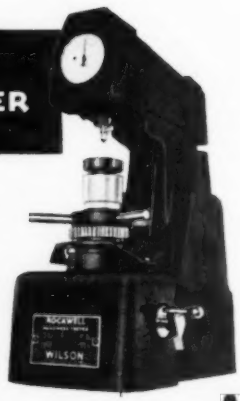
100X

Stainless Steel Surface Hardened by the Malcomizing Process of the *Chapman Valve Manufacturing Company.*

TUKON TESTER *for* **KNOOP and 136° PYRAMID HARDNESS NUMBERS**

KNOOP hardness tests were used in developing process for surface hardening stainless steel (type 410). Depth of case 0.010". The TUKON Tester may also be used for testing thin material, small specimens, small diameter wire and for many kinds of research work. A new booklet contains a collection of up-to-date information about microhardness testing facts, written by actual users of TUKON Testers. **Write for DH-7.**

"ROCKWELL" HARDNESS TESTER



for Laboratory, Tool Room, Production Line

Since 1919, WILSON has kept pace with—even anticipated—the needs of Industry in hardness-testing equipment. There has been constant improvement in existing instruments and development of new ones to meet more exacting requirements.

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ACCO

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.

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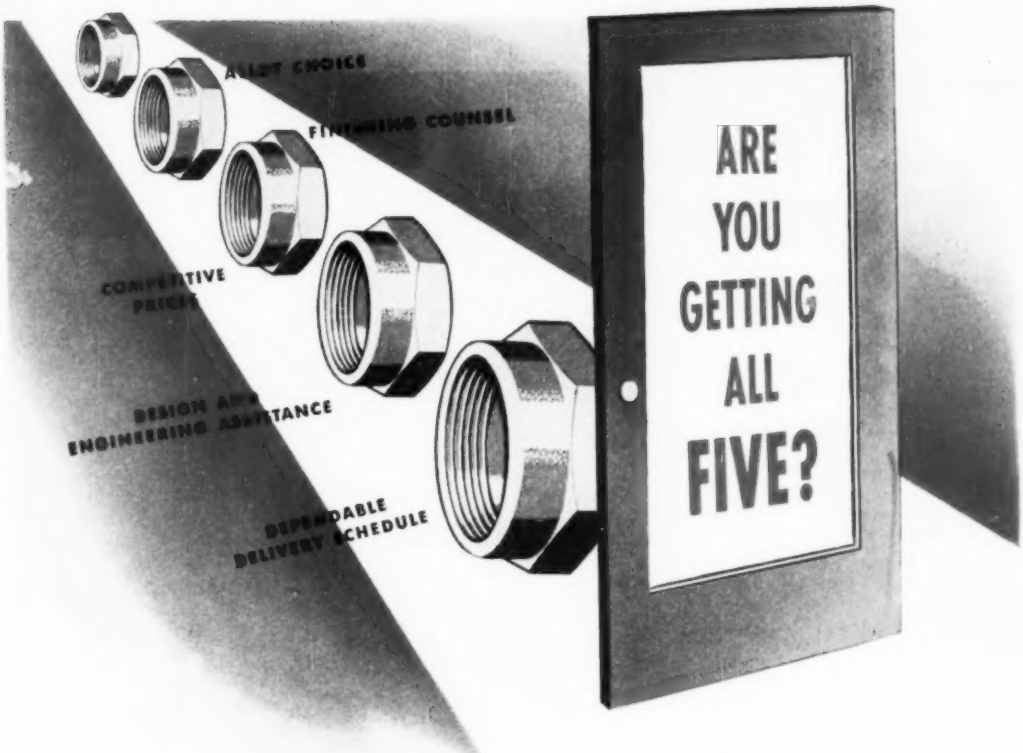
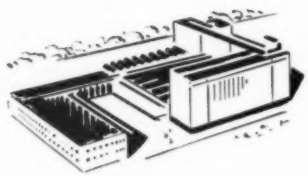


Buy screw machine parts from Alcoa—
the men who know the metal best



Complete facilities under one roof

Alcoa Aluminum screw machine parts give you strength with light weight, close tolerances where required, added sales appeal for your product.

Aluminum screw machine parts made *by Alcoa* give you even more: the know-how of the organization that pioneered aluminum in automatic screw machines; aluminum-trained experts who offer engineering, alloy choice and finish selection counsel —at no added cost to you.

You get all these plus competitive prices and dependable delivery.

Your Alcoa sales representative will be glad to give you complete information on our capacity, and a prompt quotation. Or write ALUMINUM COMPANY OF AMERICA, 2101 M Gulf Bldg., Pittsburgh 19, Pennsylvania.

ALCOA

ALCOA ALUMINUM SCREW MACHINE PRODUCTS

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
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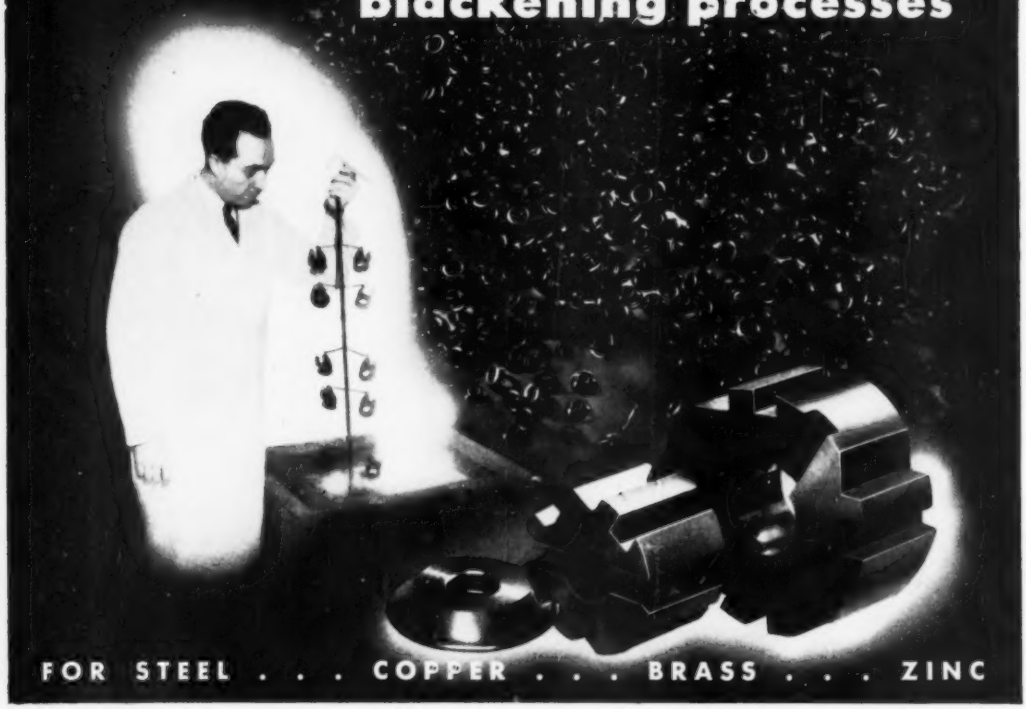
EBONOL

blackening processes



Enthone Ebonols today give new beauty, increased wearability and better functional qualities to hundreds of metal products.

The field is widely diversified: metal screens, cameras, business machines, machine tools, buttons, nameplates, dress trimmings, compacts, automobile hardware and accessories, etc.

EBONOL-C. (U. S. Patent 2,364,993) This is the best method of blackening and coloring copper and its alloys. Durable black cupric oxide is produced in a simple solution. Any metal that can be copper plated can also take this finish.

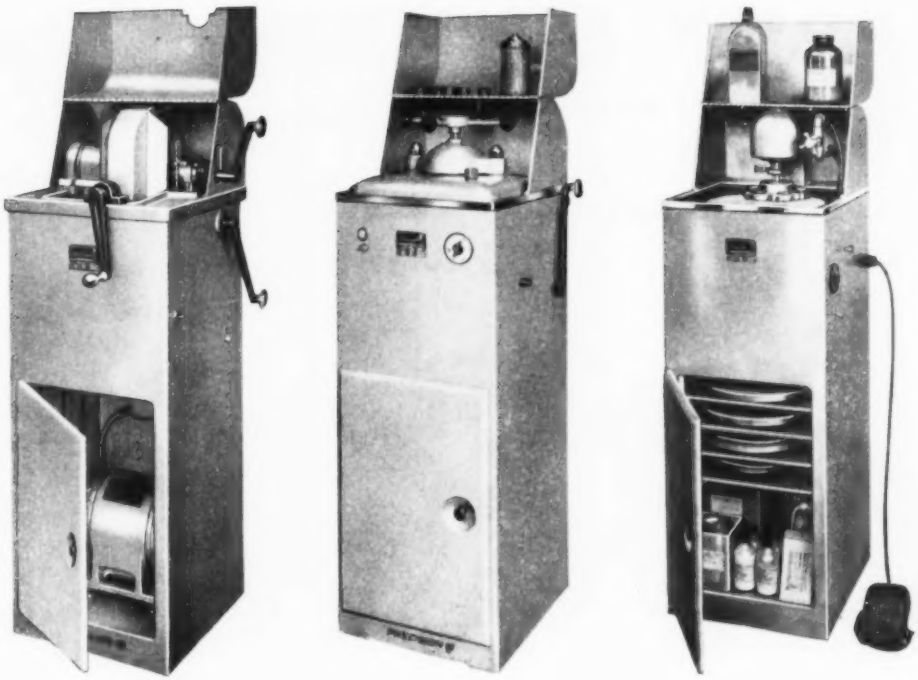
EBONOL-S. A one-bath method of blackening steel. Temperature 285 to 290° F. Simple to use and pleasant to run.

EBONOL-Z. A simple process for blackening zinc plate and zinc base diecastings. Beautiful glossy or dull finishes are achieved at low cost and trouble-free operation.

NEW TUMBLING TECHNIQUES are available for blackening and coloring. Send samples for free finishing demonstrations together with advice of experienced research chemists. *Write for new literature with procedures.*

ENTHONE INC., 442 Elm Street, New Haven, Conn.

ENTHONE
INCORPORATED



THREE *MUSTS* FOR METALLURGISTS

No Burns, no burrs, no change of microstructure when using the Precision "Subcut" Submerged Specimen Cutter; the only laboratory cutter designed to cut off the specimen while wheel and specimen are totally submerged in water—THE ONLY METHOD IN WHICH THE ELIMINATION OF BURNS IS POSITIVE.

No skilled technician or "Watch-bird" needed to operate the Precision "Aeromount" Semi-Automatic Specimen Mounting Press which gives a hard mounting, which adheres firmly to specimen, doesn't clog polishing laps and polishes down at same rate as metal specimen. The ultimate in specimen mounting.

Highly trained personnel are no longer needed and conventional hand polishing is eliminated by the use of the Precision "Polmatic" Automatic Polisher.

This machine utilizes the Precision-Jarrett Grind-Polishing principle, which means that inclusions are cut through rather than buffed or pulled out.

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Scientific Research & Production Control Apparatus

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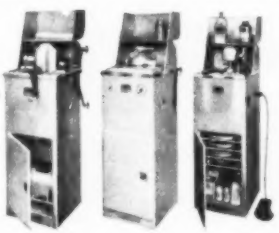

In the order of their production use, from left to right: The Precision "Subcut" Submerged Specimen Cutter. The Precision "Aeromount" Semi-Automatic Specimen Mounting Press . . . and The Precision "Polmatic" Automatic Polisher.

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CLIP AND MAIL THIS COUPON FOR METALLURGICAL CATALOG 860.-P1.

DOWN THE LINE...

WISSCO BELTS GIVE YOU ADDED MANPOWER

Wissco Belts are built to give you increased production efficiency by releasing valuable manpower for other important jobs. Eliminating batch processing, Wissco Belts require a minimum of manual attention in continuous conveyor belt operations. And time, temperature and speed can be controlled to yield uniform results.

In applications requiring resistance to terrific heat or the punishment of chemical or wet processing, Wissco Metal Conveyor Belts offer you these important advantages:

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Extreme Flexibility—*Belts will operate over small diameter pulleys.*

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Simplicity of Design—*Easily made endless; readily repaired in case of accidental damage.*

Minimum Operating Costs—*Greatest load carrying capacity per unit weight and low thermal capacity mean fuel economy.*

WISSCO METAL CONVEYOR BELTS ARE BEING USED IN:

Annealing Ovens	Decorating Glass
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Bring us your conveyor belt problems. We will be happy to cooperate in their solution. Send for our illustrated booklet on types and applications of conveyor belts.

WISSCO METAL CONVEYOR BELTS

A PRODUCT OF WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL AND IRON CORPORATION

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Pacific Coast Subsidiary—The California Wire Cloth Corp., Oakland 6, California

Candle in the Window

A bright flame in a holly-wreathed window—a solitary candle tells the tale of the ageless beauty of Christmastide. Perhaps some passerby, his heart warmed by its cheery glow, will pause before the candle and see it for what it really is—a symbol of security and peace.

We hope that you, our customers and friends, will enjoy peace and security—that the spirit of Christmas will gleam in your daily lives through the coming year. For our part, we will do our utmost to deserve your continued confidence and friendship.—*The Wisconsin Steel Organization.*

INTERNATIONAL HARVESTER

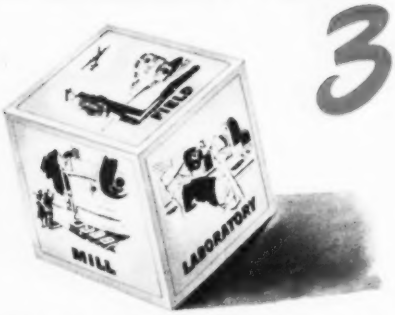
WISCONSIN STEEL COMPANY, Affiliate of INTERNATIONAL HARVESTER COMPANY

180 North Michigan Avenue • Chicago 1, Illinois

WISCONSIN STEEL

REPUBLIC Alloy Steel

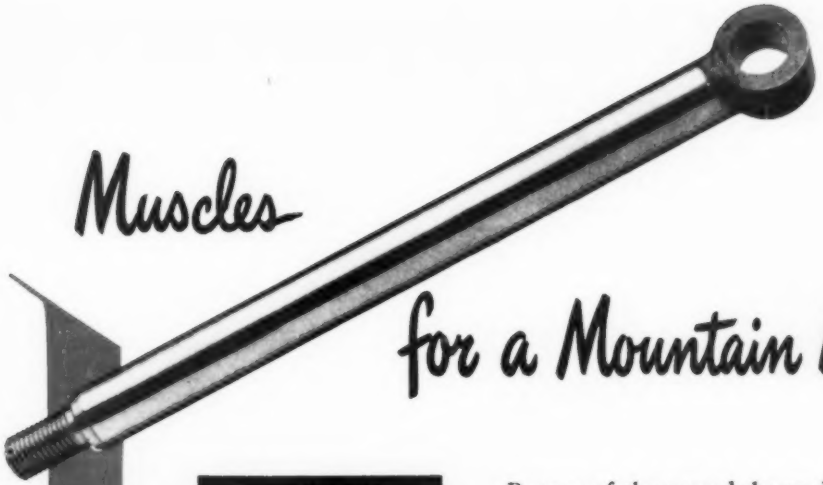
Photo courtesy of The Euclid Road Machinery Co.



3-DIMENSION *Metallurgical Service...*

In this highly intricate field of Alloy Steels, REPUBLIC'S many years of pioneering research, together with its 3-Dimension Metallurgical Service–a coordination of *Field*, *Mill* and *Laboratory* Metallurgy—have made possible many notable advances in industry after industry. These advances have paid off repeatedly for manufacturers of countless products, improved through the proper application of Alloy Steels. THEY CAN DO THE SAME FOR YOU!

Other Republic Products include Carbon and Stainless Steels — Sheets, Strip, Plates, Pipe, Bars, Wire,



Muscles for a Mountain Mover!

A REPORT FROM REPUBLIC STEEL'S *Alloy* METALLURGICAL FILES

Because of the rugged, heavy-duty service involved, this piston rod . . . "muscle" of the lift mechanism used on giant 22-ton capacity off-the-road dump trucks . . . was designed originally for alloy steel. Nevertheless, in making this vital part, the manufacturer was faced with a series of problems—difficult tolerance requirements . . . high reject losses . . . heat-treating troubles—that indicated the need for a slight change in the analysis of alloy steel used.

A REPUBLIC Field Metallurgist was called in to work with company engineers. The resulting recommendation . . . Republic heat-treated, turned and ground, stress-relieved 4140 Alloy Steel bars . . . immediately eliminated costly finishing operations and cut reject losses to an all-time low.

The selection of the proper alloy steel for any application is keyed to several vital factors . . . conditions under which the product must perform, the method and means of processing in the plant, the chemistry of the steel, and its cost—to mention only a few. And the end result of that proper selection is consistent *quality*, high *output*, low *cost* . . . the essential elements of profitable operation.

Make sure that *you* are using the Alloy Steel best suited to *your* product and process and designed to give you maximum profits—by checking first with the men who *know* Alloy Steel—the REPUBLIC Metallurgists!

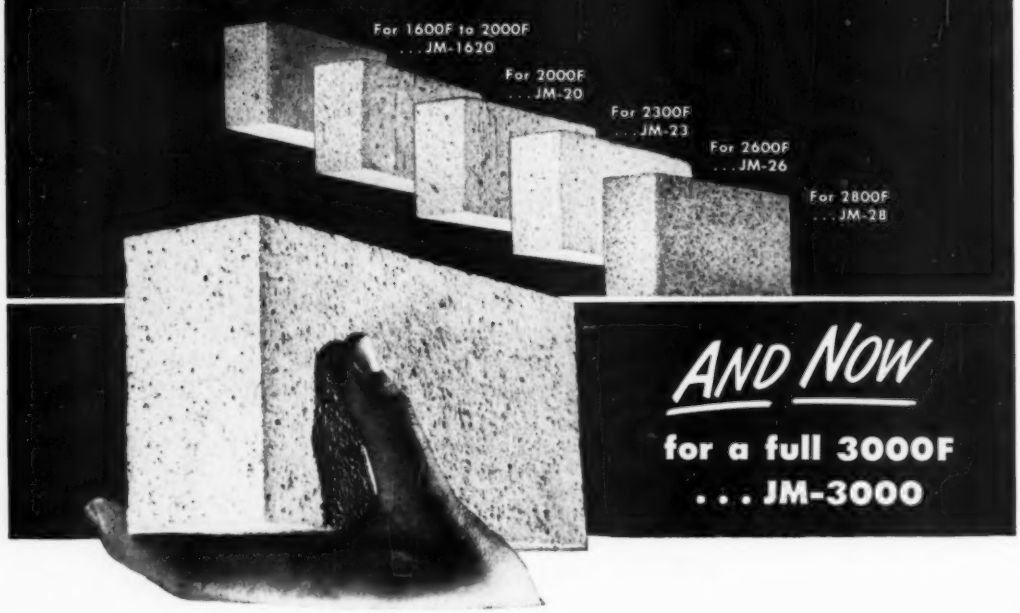
REPUBLIC STEEL CORPORATION • **Alloy Steel Division, Massillon, Ohio**
General Offices, Cleveland 1, Ohio • • • Export Department: Chrysler Building, New York 17, N. Y.

YOU, TOO, CAN BE AN EXPERT ON "PROFITS"
Wouldn't you like to have clear, concise answers to the many questions you may be asked on this all-important subject? We have them for you—in an interesting, colorful booklet written by Phelps Adams of The New York Sun. Write us for a copy.

Pig Iron, Bolts and Nuts, Tubing

Republic REPUBLIC STEEL **ALLOY STEELS**

MEET the family of Johns-Manville Insulating Fire Brick . .



HERE IS AN OUTSTANDING FAMILY of insulating fire brick for back-up or exposed use . . . the only family of its kind . . . that gives you a complete range . . . a *quick heating* insulating fire brick for every purpose.

By taking advantage of the quick heating characteristics of these insulating fire brick, you'll benefit through important savings in fuel because of the quicker rise to proper operating temperature in the furnace. This is a result of the low heat storage capacity and low thermal conductivity characteristics of the brick. These factors are especially important where furnaces are being intermittently operated.

The same materials can also be obtained in large size units as Johns-Manville Insulating Fireblok. This product has many advantages over the smaller size fire brick, from both a construction and stability standpoint. They can be quickly applied because they are easy to cut and fit. J-M Insulating Fireblok provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

Why not have a Johns-Manville insulation expert call to tell you more about ways in which you can save by using these insulations in your furnaces. Write Johns-Manville, Box 290, New York 16, N. Y. for further information.

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	120	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage,† percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.30
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

† 24-hr simulative service panel test for JM-3000, 24-hr soaking period for other brick.

* Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville First in INSULATIONS

make either operation easier with

WEIRTON

HIGH-CARBON STRIP

COLD-ROLLED SPRING STEEL

Whether you use cold-rolled spring steel for blanking or for forming, there is a Weirton high carbon strip that simplifies production and holds down costs.

Weirton's close control over every phase of manufacture is your assurance of a consistent balance of desirable qualities and properties. You can depend on Weirton High-Carbon Strip for accurate response to heat treatment—uniformity of gage and width—uniform chemical and physical properties—exact constancy of grain structure—controlled decarburization limits. In other words—Weirton High-Carbon Strip makes good products better, helps you make them more economically.

Weirton High-Carbon Strip is obtainable with the desired chemical analysis and for specific heat treating and hardness ranges, in widths up to seven inches.

SPHEROIDIZED
Annealed, soft and ductile—ideal for cold forming operations.

PEARLITIC
Temper-rolled in controlled hardness and strength for blanking.

WEIRTON STEEL CO.

WEIRTON, W. VA., Sales Offices in Principal Cities

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pennsylvania*

One Thousand, Nine Hundred Forty Nine Times

— this world has celebrated the Birthday of an Idea more precious than the material treasure of a universe — celebrated by festival and the giving of gifts — and men and the children of men have found Happiness in this Day. It is indeed a Pleasant Belief founded upon a spirit of universal fraternity, material helpfulness and personal sacrifice to Friendship.

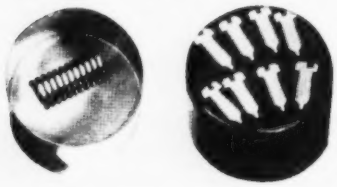
But far more than one thousand, nine hundred forty nine times each year we pay tribute to this great and fundamental spirit of our lives. We give and receive every hour from the cradle to the grave — gifts as intangible and priceless as a Cheerful Word.

— and these things take hold of our destiny — building the Friendships that carry us up through the years. What a dramatic story for each of us would be a complete and faithful record of all we have given and received. If it were printed and bound we would hold such a book beyond price. For Reciprocal Benefit is the True Gold of our Existence. Are we conscious enough of this Wealth—have we a plan for this house we are building? For as surely as rivers flow down to the sea, the friendships that flow into our lives will determine our level. — and as truly as though it were quoted, as we Give so shall we Receive.

One thousand nine hundred forty nine times men have wished one another "Merry Christmas." May our own wish to you stand out sincerely in the midst of Holiday Repetition.

"MERRY CHRISTMAS"

—and may the sand in the hour glass of your New Year be heavy with grains of gold.



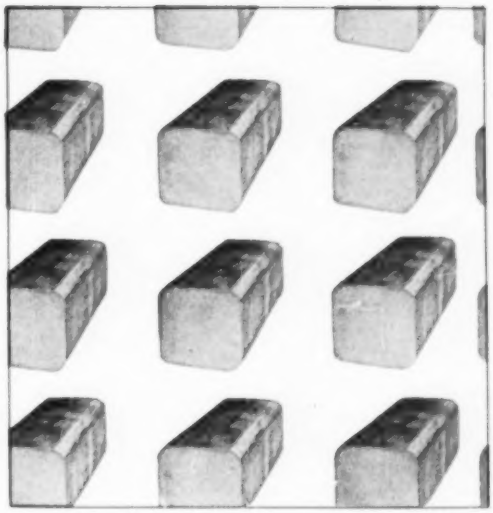
Buehler Ltd.

A PARTNERSHIP

METALLURGICAL APPARATUS

165 West Wacker Drive, Chicago 1, Illinois

Why you get the most for your money with TIMKEN® forging bars



1. SUPERIOR SURFACE AND INTERNAL QUALITY

2. UNIFORM FORGEABILITY IN EVERY BAR, EVERY HEAT

NO matter what analysis of Timken forging bars you use, you get superior surface and internal quality plus uniform forgeability from heat to heat, bar to bar.

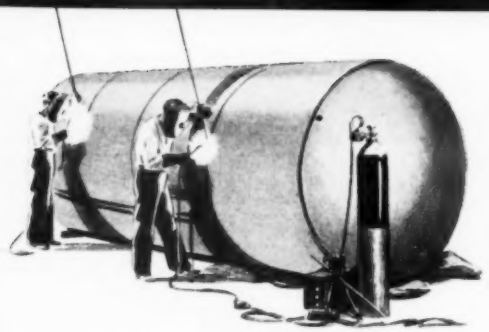
This means better forgings at less cost for you. Your forgings have uniformly high quality, uniform physical properties, and uniform response to heat treatment. Your production costs are cut through fewer rejects, fewer delays and fewer changes in shop practice.

The uniformly high quality of Timken forging bars is something you can depend on. It is rigidly and completely controlled by The Timken Roller Bearing Company every step of the way—from melting through final inspection. What's more, The Timken Company use many special practices—practical only in a large, flexible specialty mill—and leads the field in alloy steel experience and research.

Write today for an "on-the-job" analysis by our Technical Staff. No obligation. Ask also for our 112-page book of forging data, "Evaluating the Forgeability of Steels". The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

50th birthday of the company whose products you know by the trade-mark: TIMKEN

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

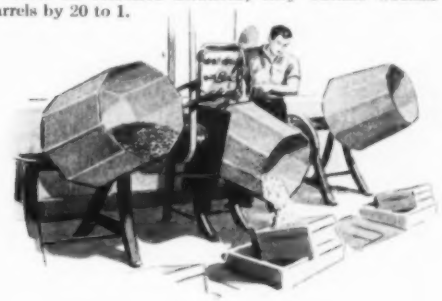


LIQUID OXYGEN + FINE CARBON = BOOM

In some coal mines, a mixture of liquid oxygen and finely divided carbon is used for blasting. This 4,000-gallon liquid oxygen storage tank was fabricated by L'Air Liquide Society, Montreal, Canada. Made of Everdur† for strength and corrosion resistance, 150 feet of seams were arc-welded by the inert-atmosphere process using water-cooled torches.

TUMBLING FOR 10 YEARS

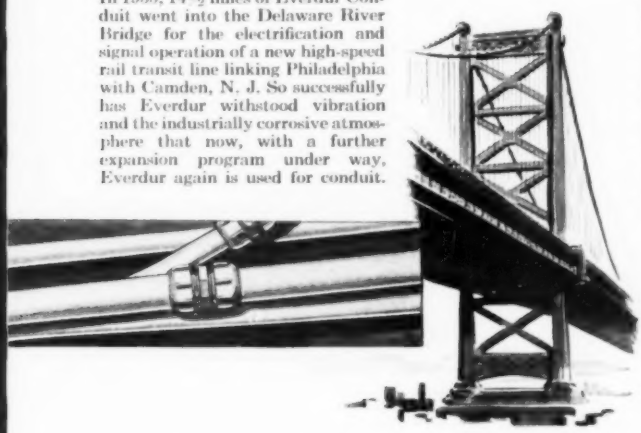
This isn't an act, it's a record—up to now—for this battery of three tumbling barrels made of Everdur. Used for wet tumbling, polishing and lustering of light metal products in corrosive solutions, they outlast wooden barrels by 20 to 1.



EVERDUR* goes everywhere...

14½ MILES—14½ YEARS

In 1935, 14½ miles of Everdur Conduit went into the Delaware River Bridge for the electrification and signal operation of a new high-speed rail transit line linking Philadelphia with Camden, N. J. So successfully has Everdur withstood vibration and the industrially corrosive atmosphere that now, with a further expansion program under way, Everdur again is used for conduit.

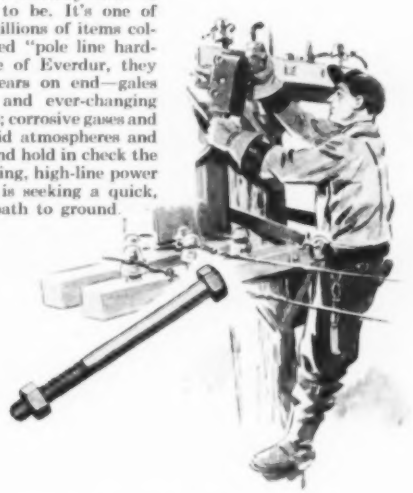


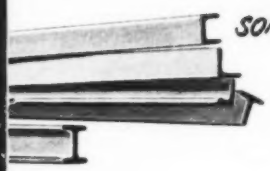
ONE IN A MILLION

†REG. U. S. PAT. OFF.

This isn't an ordinary bolt—it can't afford to be. It's one of uncounted millions of items collectively called "pole line hardware." Made of Everdur, they resist—for years on end—gales and storms and ever-changing temperatures; corrosive gases and vapors; humid atmospheres and saline fogs, and hold in check the anxious, surging, high-line power that forever is seeking a quick, destructive path to ground.

6131





SOMETHING NEW HAS BEEN ADDED

This is just to let you know that Everdur structural shapes are now available from stock in angles, channels, Tee shapes and "I" beam sections. Address The American Brass Company, 70 Sayre Street, Buffalo 5, New York.

P.S. HOW ABOUT SENDING IN YOUR STORY ON EVERDUR?

WANT TO KNOW MORE?

Our Technical Department has a wealth of information on the properties and applications of Everdur. Write to The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6131

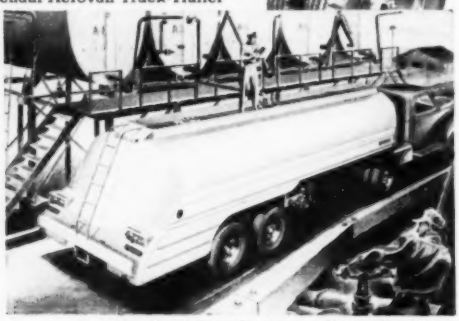
Where corrosion resistance counts

ANACONDA

COPPER-SILICON ALLOYS*

YOLOY SAVES . . .

Yoloy framing of the
Fruehauf Aerovan Truck-Trailer



Fruehauf Tank-Trailer has Yoloy Steel tank

. . . *saves* WEIGHT . . .
SPACE . . . MAINTENANCE AND
REPAIR . . . FUEL AND OIL COST . . .
TIRE WEAR . . . OVER-ALL EXPENSE

USERS of Fruehauf Truck-Trailers enjoy the many advantages of lighter weight body construction made possible through the use of Yoloy high-strength steel.

Structural members of Yoloy are light in weight, yet have the strength of conventional steels much heavier and thicker. Yoloy reduces vehicular dead weight and permits extra payload. Being a nickel-copper steel of outstanding toughness, Yoloy is also highly corrosion resistant, shock resistant and durable. Yoloy is available in sheets, plates, strip, bars and tubular products.

QUALITY YOUNGSTOWN SERVICE

Youngstown
YOLOY STEEL

THE YOUNGSTOWN SHEET AND TUBE COMPANY General Offices — Youngstown 1, Ohio

Manufacturers of Carbon, Alloy and Yoloy Steel Export Office - 500 Fifth Avenue, New York

COLD FINISHED CARBON AND ALLOY BARS - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - WIRE - PIPE AND TUBULAR PRODUCTS - CONDUIT - RODS - SHEETS - PLATES - BARS - RAILROAD TRACK SPIKES.

Now-Safer than ever!

Read the Facts About the New Model 1300 FLAME-OTROL

Learn... how the Wheelco FLAME-OTROL now renders more positive and dependable protection to all types of gas and oil fired heating equipment from safe-start to safe shut-off:

...how the many new protective features of this improved Wheelco FLAME-OTROL give you a Combustion Safeguard—"safer than ever."

APPROVED BY ASSOCIATED FACTORY MUTUAL AND UNDERWRITERS' LABORATORIES

- ✓ Guaranteed Safe-Start
- ✓ Instantaneous Action
- ✓ Continuous Supervision
- ✓ Versatility of Operation
- ✓ Fully Shielded Circuit
- ✓ Design Simplicity
- ✓ Program Variety
- ✓ Front Accessibility
- ✓ Voltage Selector Plugs
- ✓ Blue Sensitive Cell

WHEELCO INSTRUMENTS COMPANY
835 W. Harrison St. • Chicago 7, Illinois

Please send me Bulletin F2-1

Name _____ Title _____

Company _____

Street _____

City _____ Zone ____ State ____

WHEELCO *Electronic* CONTROLS

RECORDERS • COMBUSTION SAFEGUARDS • CONTROLLERS

Here's A New Stainless Bar Grade

WITH 8 UNUSUAL ADVANTAGES

If your products require extra strength and hardness *combined with excellent corrosion resistance,* you'll be interested in the revolutionary new properties of Armco 17-4 PH Stainless Steel bars and wire.

This new precipitation hardening grade, a development of Armco Research, offers you an exceptional combination of 8 advantages:

1. It is hardenable by heat treatment to Rockwell C-40/45.
2. This hardness is obtained by heat treating in *the low range* of 850-900° F. for one hour, and air cooling.
3. Only a superficial, easy-to-remove heat tint results from the heating operation. This means that close tolerance parts can be finish-machined before hardening—eliminating finish machining or grinding after hardening.
4. Because of low hardening temperatures, distortion is virtually eliminated.
5. Freedom from hardening cracks.
6. Stress relieving treatment is not needed with Armco 17-4 PH Stainless Steel.
7. Machinability is good (between Types 302 and 303) in the annealed condition; fair when the steel is fully hardened. It can be readily hot worked and has good welding properties.
8. Its corrosion resistance is close to that of Types 302, 303, and 304.

Armco 17-4 PH may be just the stainless steel you need for better product performance or to solve special fabricating problems. For complete information, just fill in and mail the handy coupon. Armco Steel Corporation, 4169 Curtis Street, Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION.

MAIL TODAY FOR MORE DATA

Armco Steel Corporation, 4169 Curtis Street, Middletown, Ohio

Send me complete information on Armco 17-4 PH.

NAME_____ TITLE_____

FIRM NAME_____

STREET_____

CITY_____ ZONE____ STATE_____

ARMCO STEEL CORPORATION

ARMCO

This is a typical list of manufacturers who, since the end of the war, have purchased Sunbeam STEWART FURNACES to help reduce costs and keep themselves competitive

A
Abraff Mfg. Corp.
Acker & Man, Inc.
Adams Construction Co.
Addressograph-Multigraph
Advertising Metal Display
All-Steel Equip. Co.
Allbright-Nell Co.
Allen Bradley Co.
Allen Mfg. Co.
Allis-Chalmers Mfg. Co.
Altorfer Bros. Co.
Aluminum Co. of America
American Air-Filter Co. Inc.
American Airlines Inc.
American Ball Bearing Corp.
American Brake Shoe Co.
American Brush Corp.
American Can Co.
American Cast Iron Pipe Co.
American Chain & Cable Co. Inc.
American Electric Fusion Corp.
American Hardware
Corbin Cabinet Lock Div.
American Hollow Boring Co.
American Instrument Co., Inc.
American Meter Co., Inc.
American Optical Co.
American Phenolic Corp.
Anderson-Carlson Mfg. Co
Anderson Co.
O. L. Anderson Co., Inc.
Apex Smelting Co.
Armstrong Cork Co.
Art-Craft Optical Co., Inc.
Atchison, Topeka & Santa Fe Ry. Co.
Auto Spec. Mfg. Co.
Automatic Electric Co.
Automatic Gas Co. of Columbus, Inc.

B
Badger Tool & Eng. Co.
B. A. Ballon & Co., Inc.
The Bassick Co.
C. J. Bates & Sons
Bauer & Black Div., Kendall Co.
Bayuk Cigars, Inc.
Beatrice Steel Tank Mfg. Co.
Bell & Gossett Co.
Bell & Howell Co.
Belle City Mfg. Co. Inc.
Bendix Aviation Corp.
L. A. Benson Co. Inc.
Bernardin Bottle Cap Co. Inc.
Blizzard Mfg. Co.
Blue Ridge Pressure Castings
Bolens Products Co.
Bonney Forge Tool Works
Boston Wire Stitcher Co.
James H. Boye Mfg. Co.
Brasco Mfg. Co.
Chas. D. Briddell, Inc.
Bristol Co.
Broderick Co.
D. S. Brown Co.
Bucyrus-Erie Co.
Edw. G. Budd Co.
Buick Oldsmobile Pontiac Assembly Div., General Motors Corp.
Burgess-Norton Mfg. Co.
Burndy Eng. Co. Inc.

C
Caine Steel Co.
Cameron Mfg. Corp.
Carbo Tool & Die Co.
Carnegie-Illinois Steel Corp.
Certain-Teed Prod. Corp.
W. M. Chace Co.
Chain Belt Co.
Chamberlain Corp.
Cherry-Burrell Corp.
Chicago Auto Spring Co.
Chicago & North Western Ry. Co.
Chicago Pneumatic Tool Co.
Chicago Rawhide Mfg. Co.
Chicago, Rock Island & Pacific RR Co.
Chicago Screw Co.
Chicago, South Shore & South Bend RR
Chopie Tool & Die Co.
Chrysler Corp.
W. M. Cissell Mfg. Co.
Clayson-Forenz Co.
Clifton Conduit Co.
Colgate Mfg. Corp.
Collyer Insulated Wire Co., Inc.
Corn Products Refining Co.
Cummins Business Machines
Cutler-Hammer, Inc.

D
Davis & Furber Mach. Co.
Day Brite Lighting, Inc.
Deere & Co.
Detroit Gear Div., Borg-Warner Corp.
Detroit Stamping Co.
Diamond Expansion Bolt Co., Inc.
Doehler-Jarvis Corp.
Dole Valve Co.
E. I. DuPont de Nemours & Co., Inc.
Dynamatic Corp.

E
Eagle Pencil Co. Inc.
Eastman Machine Co.
Eclipse Sleep Products, Inc.
Ehlert Tool Eng. Co.
Electric Storage Battery Co.
Emerson Electric Mfg. Co.
Essex Wire Corp.
Chicago Transformer Div.
R-B-M Div.
Eveready Tool Co.
Eversharp, Inc.

F
Fafnir Bearing Co.
Ferrara Spring & Parts Co., Inc.
Fischer & Porter Co.
Michael Flynn Mfg. Co.
Foreman Mfg. Co.
Frazer & Jones Co.

G
General Cable Corp.
General Electric Co.
General Motors Corp.
Electro-Motive Div.,
Frigidaire Div.
General Tool & Die Corp.
Gerotor May Corp.
Gibson Refrigerator Co.
Girard Mfg. Co.
Gisholt Machine Co.
Great Lakes Spring Corp.
Green Bay Drop Forge Co.

H
Hammond Brass Works
Harrington & King Perforating Co.
Hartford Machine Screw Co.
J. F. Helmhold & Bro.
Hi Level Screw Prod. Co.
High Speed Hammer Co. Inc.
Hotpoint, Inc.
Houdaille-Hershey Corp.
General Spring Bumper Div.
Huntington Div.
Oakes North Chicago Div.
M. D. Hubbard Spring Co.
B. H. Hubbard & Son, Inc.
Hummer Mfg. Co.
Hy-Pro Tool Co., Inc.
Hydraulic Press Mfg. Co.

I- Illinois Tool Works
International Projector Corp.
J International Tool & Gauge Co.
James Mfg. Co.
Johnston Lawn Mower Corp.
Jones & Laughlin Steel Corp.
A. D. Joslin Mfg. Co.

K
Kent Galvanizing Co.
Kewanee Mach. & Conveyor Co.
Klein Mfg. Co.
Kraeuter & Co., Inc.
Kropp Forge Co.

L
L-S Mfg. Co.
A. Lakin & Sons
Landis Machine Co.
Leach Co.
Ledkote Products Co.
Leman Machine Co.
Line Material Co.
Link Belt Co.
Lloyd Mfg. Co.
Lobdell-Emery Mfg. Co.
Locke Insulator Corp.
Louden Machinery Co.
Lux Clock Mfg. Co.

M
Macey Co., Div. Earle S. Irwin Co.
Magnetics, Inc.
Malleable Industries
Manganese Steel Forge Co. Inc.
Manufacturers Machine & Tool Co.
Marathon Elec. Mfg. Co.
McGraw Electric Co.
McHenry Mfg. Co.
Mid-States Steel & Wire Co.
Midwest Brass Forging Co.
Milford Metal Treating Co.
Milford Plastic Tool Corp.
Minneapolis-Honeywell Regulator Co.
Modine Mfg. Co.
Mojonnier Bros. Co.
Monarch Marking System Co.
Mossberg Pressed Steel Corp.
Chas. Mundt & Sons

N
Nachman Corp.
Nash-Kelvinator Corp.
National Elec. Welding Machine Co.
National Enameling & Stamping
National Pressure Cooker Co.
National Rivet & Mfg. Co.
New Jersey Instrument Corp.
New Monarch Machine & Stamping Co.
Newark Stove Co.
Northern Electric Co.
Northern Pacific Railway Co.
Northwest Metal Prod. Inc.

O- Ohio Brass Co.
Oliver Corp.
P Pacific States C. I. Pipe Co.
Paramount Wedding Ring Co.
Pearlduck, Inc.
Peerless Roll Leaf Co. Inc.
Penn Rivet & Machine Co.
Petersen Mfg. Co.
Phelps Dodge Corp.
Philco Corp.
Pick Mfg. Co.
H. K. Porter Co.
American-Fort Pitt Spring Div.
Precision Mfg. Co.
Progressive Mfg. Co.

R
Radio Corp. of America
R. J. Randel Tool Co.
Manhattan Rubber Mfg. Div. of Raybestos-Manhattan, Inc.
F. B. Redington Co.
W. H. Reisner Mfg. Co. Inc.
Reliable Electric Co.
Remington Rand, Inc.
Republic Steel Corp.
Rewelec Mfg. Co.
Rheem Mfg. Co.
Richardson Scale Co.
Richmond, Fredericksburg & Potomac RR Co.
Roy E. Roth Co.
Wm. & Harvey Rowland, Inc.
Royal Typewriter Co.
Ruud Mfg. Co.
Jos. T. Ryerson, Inc.

S
Safety Socket Screw Co.
Sager Lock Works
Schultz Die Casting Co.
Scovill Mfg. Co.
Seneca Wire & Mfg. Co.
Servel, Inc.
W. A. Shaeffer Pen Co.
Shepard Niles Crane & Hoist Corp
R. H. Sheppard Co. Inc.
A. O. Smith Corp.
Solomon Sokoloff
South Bend Lathe Works
Sperti Faraday, Inc.
St. Joe Machines, Inc.
St. Louis Southwestern Ry. Co.
St. Louis Steel Castings Co.
Staatsburg Ice Tool Works
Standard Dredging Corp.
Standard Shade Roller Corp.
Standard Steel Spring Co.
Steel Fabricating & Engineering Co.
Stewart Die Casting Div.
Stockham Pipe Fittings Co.
Sylvania Industrial Corp.

T
Tait Mfg. Co.
Tennessee Coal, Iron & R. R. Co.
Texas Co.
Thomas & Skinner Steel Products Co.
Tillotson Mfg. Co.
Timken Roller Bearing Co.
Tobin Tool & Die Co.
Townsend Co.
Triangle Auto Spring Corp.
Triplett Electrical Instrument Co.
Tube Turns, Inc.

U- U. S. Cloth Cutting Mach. Co.
V U. S. Metals Products
United-Carr Fastener Corp.
Universal Chain Co. Inc.
Universal Oil-Seal Co.
Ushco Mfg. Co., Inc.
Vince Forging & Mfg. Co.
Vollrath Non-Ferrous Metal Foundry

W
Waterloo, Cedar Falls & Northern RR
Watson Elevator Co. Inc.
Waukesha Motor Co.
Weaver Mfg. Co.
Webster Electric Co.
Western Electric Co., Inc.
Wetmore Reamer Co.
Wisconsin Knife Works
John Wood Mfg. Co., Inc.
Woodring & Wise Machine Shop

Y- Yale & Towne Mfg. Co.
Z Ypsilanti Reed Furniture Co.
Zenith Radio Corp.

Sunbeam
STEWART INDUSTRIAL FURNACES
A DIVISION OF Sunbeam CORPORATION

(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 108, 4433 Ogden Ave., Chicago 23

New York: 322 W. 48th St. *Detroit:* 3049 E. Grand Blvd.

Canada Factory: 321 Weston Rd., So., Toronto 9

A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM STEWART furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM STEWART engineer will be glad to call and discuss your heat treating problems with you.

Mail this coupon for complete information on furnaces to meet your needs:

- ☐ Atmosphere-controlled
- ☐ Bonderizing
- ☐ Brazing furnace
- ☐ Car bottom
- ☐ Case hardening
- ☐ Combination
- ☐ Complete toolroom
- ☐ Continuous production heat treat line
- ☐ Electric high speed
- ☐ Electric pre-heat
- ☐ Forging
- ☐ Galvanizing
- ☐ Gas carburizing
- ☐ Gas nitriding
- ☐ High speed steel
- ☐ Metal melting
- ☐ Oven
- ☐ Pot
- ☐ Recirculating
- ☐ Rivet heaters
- ☐ Rotary hearth forge
- ☐ Soldering iron heaters
- ☐ Tempering
- ☐ Tool hardening

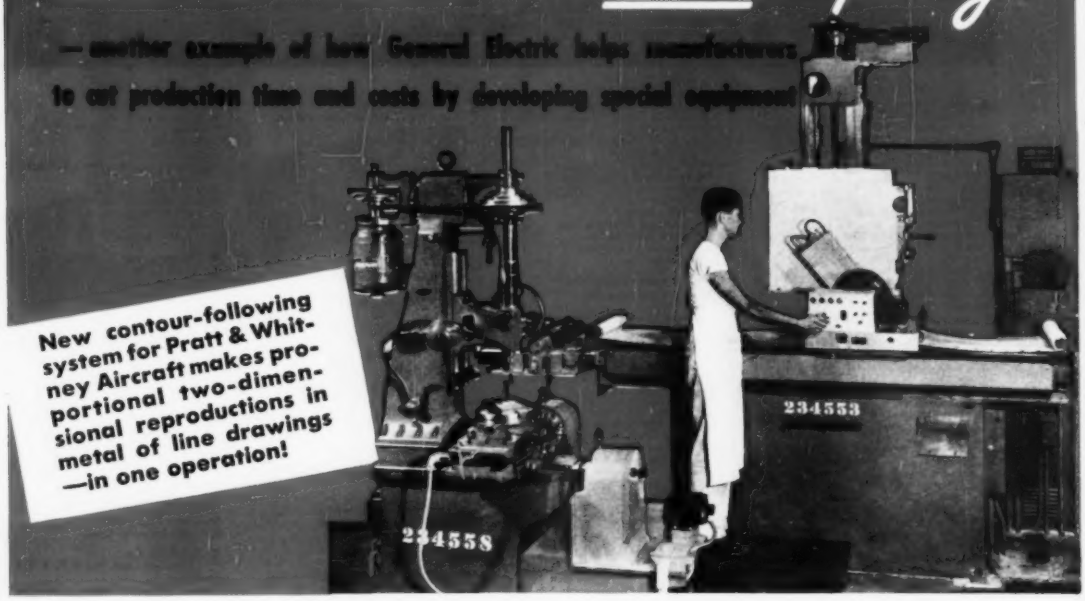
Name _____ Title _____

Company _____

Address _____

NEEDED . . . equipment for "Metaltelepathy"

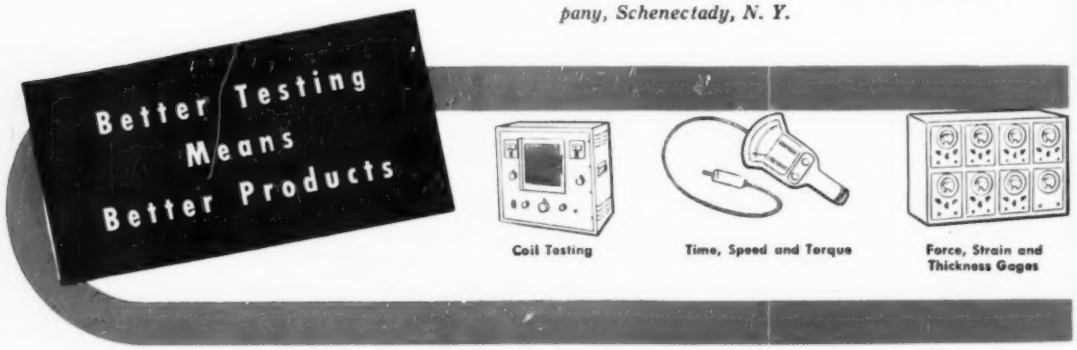
— another example of how General Electric helps manufacturers to cut production time and costs by developing special equipment



When seeking a way to make two-dimensional reproductions in metal of line drawings, which would speed up the production of air-foil metal master patterns, engineers at Pratt & Whitney Aircraft called in General Electric. Working closely with Pratt & Whitney Aircraft engineers, G-E designers developed a new type of contour-following system. Cost of this equipment is justified for this special application because the system cuts the cost of producing a new metal master pattern by about 75 per cent and reduces production time by about 80 per cent. Although not applicable to conventional production, the equipment gives Pratt & Whitney Aircraft a valuable new tool.

A G-E Instrument for Your Problem

You may find that G-E engineers can help you by recommending one of the many stock G-E devices and instruments. Your problem, especially if it is one common to industry, may even justify developing new equipment. Write today for help to *Apparatus Department, General Electric Company, Schenectady, N. Y.*



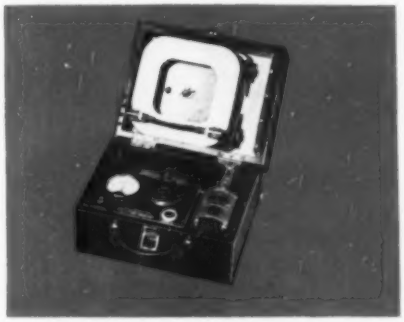
THERE ARE G-E TESTING AND MEASURING EQUIPMENTS FOR NEARLY EVERY INDUSTRIAL PROCESS

To Cut Costs of Manufacturing or Servicing Rotating Machines

—use the G-E portable dynamic balancer

By using the G-E portable dynamic balancer to balance rotors in their own bearings, you can drastically reduce the time and cost of balancing rotors in generators, motors, and in other rotating machines. The balancer is easy to use and saves time. One operator alone can balance two-bearing machines, and he needs to make only three runs.

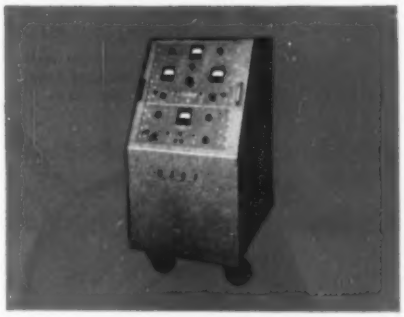
Ideal for factory-testing rotating machines, the balancer is portable. You can use it for installation or maintenance work, and for field service on any rotor within a speed range of 600 to 6000 rpm and weighing more than 30 pounds. Write for GEA-320.



To Locate Leaks in Closed Systems

—use the G-E Type M Leak Detector

By locating even the smallest leaks while your products are on the production line, you reduce operating costs, cut service expense in the field—and safeguard the good will of your customers. Used in G-E refrigerator production for more than two years, the Type M detector uses helium as the tracer. The detector is so sensitive that it can detect one part of helium in 200,000 parts of air. Write for GEC-336.

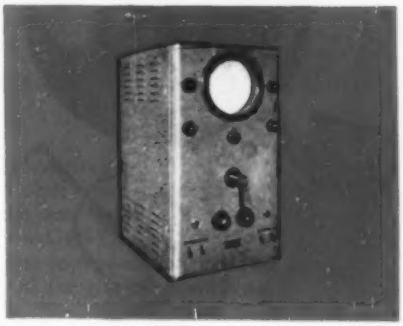


To Detect Insulation and Winding Faults Quickly

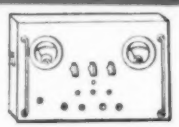
—use the G-E winding-insulation tester

You can speed up production-line testing of motors, transformers, and generators by using the G-E winding-insulation tester. At one G-E plant, for example, more than 4000 motors a week are tested with one device.

Less than one minute is required for a complete test, which includes resistance, impedance, turn-balance, and complete high-potential tests. The operator can determine the nature of defects by the wave shapes of the oscillograms on the screen of the tester. Write for GEC-321.

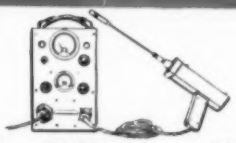


Materials Testing



Chemical Analysis

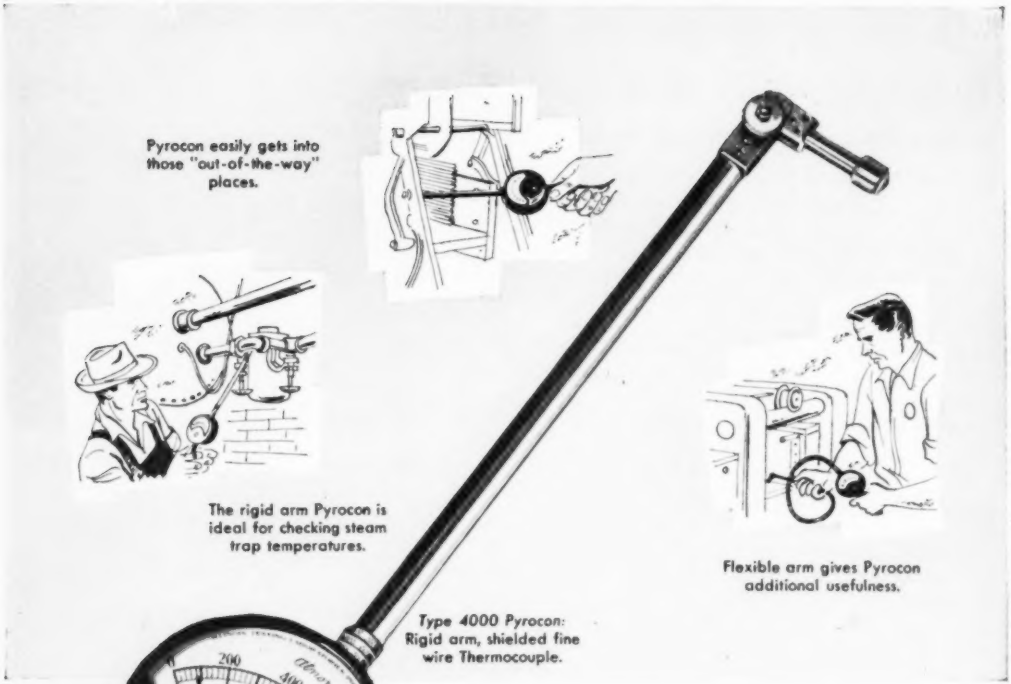
Insulation Tester



Leak Detector

Vibration and Sound

GENERAL ELECTRIC



Type 4000 Pyrocon: Flexible arm, shielded fine wire Thermocouple

Take any surface temperature *Quickly, Accurately* with the handy **PYROCON!**

AMONG portable pyrometers the Pyrocon sets new standards for accuracy and fast indications! And its usefulness extends to almost every case where surface temperatures must be closely watched. Available with any or all of ten interchangeable thermocouples, (no recalibration required after changing) the well-balanced hand-held Pyrocon is used in every industry . . . die-casting, plastics, rubber and paper processing, refinery service, etc. Readings are fast and, like all Alnor instruments, the Pyrocon's accuracy is of laboratory quality.

TAKE A MINUTE to get the whole story!
Use this coupon to get your copy of Bulletin 4257. We promise you, you'll be glad you did.
. . . Alnor Representatives are conveniently listed in classified directories in over 24 major cities.

ILLINOIS TESTING LABORATORIES, INC., Room 823
823 N. La Salle Street, Chicago 10, Illinois
☐ Send me Bulletin No. 4257
☐ Have Alnor representative call
Name.....
Company Name.....
Address.....
City.....State.....

Alnor **PRECISION INSTRUMENTS FOR EVERY INDUSTRY**

ILLINOIS TESTING LABORATORIES, INC.
Chicago 10, Illinois

"8 years of trouble-free operation with GULF HARMONY OIL"

says this foreman

"no overhauls or oil changes necessary on this press during that period"

"During eight years of operation we've never found it necessary to overhaul this straightening press for any reason," says the Foreman of a Midwestern manufacturing plant. "Periodic checks have revealed little or no leakage through oil seals, a complete absence of oil sludge in valves, lines, and sump, and a minimum of wear in all moving parts.

"We know this record wouldn't have been possible without a hydraulic fluid of the caliber of Gulf Harmony Oil. The fact that we have never found it necessary to replace the original charge is ample evidence that it doesn't form sludge, and the absence of mechanical trouble during the entire eight years indicates that this oil has excellent lubricating qualities."

A typical case of the satisfaction expressed by users of Gulf Harmony Oil, which is establishing performance records in the hydraulic systems of hundreds of presses, machine tools, and other types of metalworking equipment. High resistance to oxidation, an effective corrosion inhibitor, and Gulf's patented anti-foam agent are a few of the reasons for its fine performance.

Call in a Gulf Lubrication Engineer today and ask him to recommend the proper grade of this quality oil for your hydraulic machines. It can help you improve equipment performance and reduce maintenance costs. Write, wire or phone your nearest Gulf office.

Gulf Oil Corporation · Gulf Refining Company

Offices in Principal Cities in 30 States

GULF INDUSTRIAL LUBRICATION

When your product needs a lift

Hitch on to this star!

DON'T think of Allegheny Ludlum as a steel producer in the ordinary sense. We don't make "ordinary" steels.

Our job is to create and develop materials in the special alloy field: stainless and heat-resistant steels, tool and die steels, carbide metals, special electrical and magnetic materials, and super-alloy steels for high temperature service. The function of these products is either to do existing jobs better than ordinary steels or other materials can do them; or to reach out into new fields and do jobs that previously couldn't be done at all. In practically every case, the use of these special alloy steels proves not only to be economically sound, but actually cheapest in the long run.

Do you want to *add* something to present products: longer life, more wear, better looks, greater strength, less weight, finer performance? *Let us help you do it.* Do you have a new device, or re-design, still in the "good idea, but haven't found the right material" stage? *Call us in—that's our job!*

Complete technical and fabricating data—engineering help, too—yours for the asking. W&D 2350

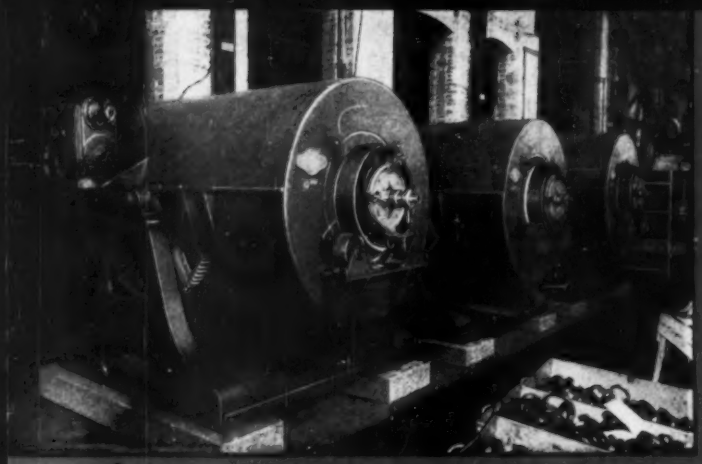
ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

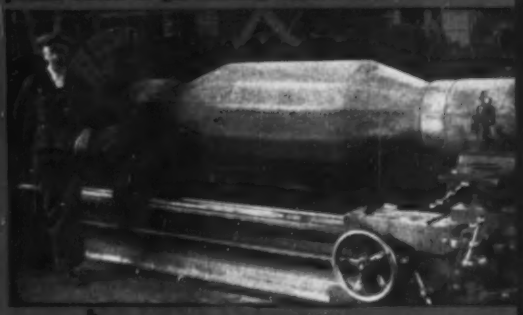
Pittsburgh, Pa. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses



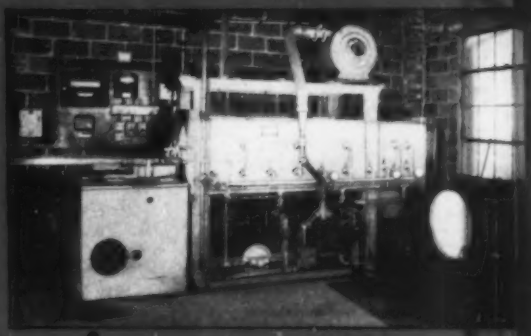
a

Furnaces shown are engineered and manufactured by American Gas Furnace Co., Elizabeth, N. J.—the pioneer builder of gas furnaces, founded 1878.

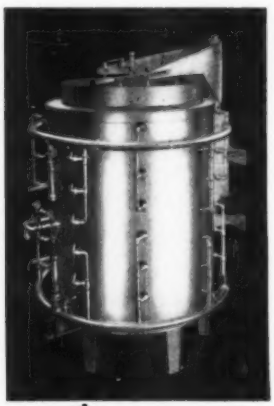


b

Life begins at 10,000 hours with NICHROME*



c



d

FOR over 30 years, Driver-Harris has been engineering and casting high heat-resisting nickel-chrome alloys . . . finding the answer to a multitude of heat-treating problems. Result: Furnace parts and heat-treating equipment that are unexcelled for efficiency, economical service, and *long life*.

These pictures, showing various types of furnaces, illustrate typical examples of D-H long-life furnace parts in action, in equipment made by American Gas Furnace Company:

A—Rotary Gas Carburizers which, in addition to carburizing, are well adapted for hardening, annealing, or normalizing in controlled atmospheres. Large Nichrome retorts (average capacity: 1,800-lbs. of work) have served up to *24,000 hours* apiece in these machines, at temperatures between 1500° and 1650°F.

B—This Twenty-two Hundred Pound Retort, receiving its final machining for use in the type of furnaces shown in "A", is typical of the big applications the heat-treating industry has found for versatile Nichrome.

C—Nichrome muffles in this Reciprocating Muffle Furnace, operating at temperatures between 1550° and 1700°F., have stayed on the job for as long as *12,000 hours without requiring attention* . . . gone back to work for several thousand more after receiving only minor repairs. Furnace capacity: 150 - 300 lbs. per hour. Used for carburizing, hardening and annealing.

D—Vertical Carburizing Furnace, operating at temperatures approximating 1650°F., in which a Nichrome retort, of 30" inside diameter, has given 36,000 hours of highly efficient, dependable service.

And as with Nichrome, so with other D-H cast alloys, such as Chromax* and Cimet*, whose excellent oxidation resistance and strength at elevated temperatures make them unsurpassed for conventional applications, indispensable in the case of extraordinary problems. So specify D-H alloys, to get improved heat transfer, shorter heating and cooling cycles, and, most important of all, *lower heat-hour costs*.

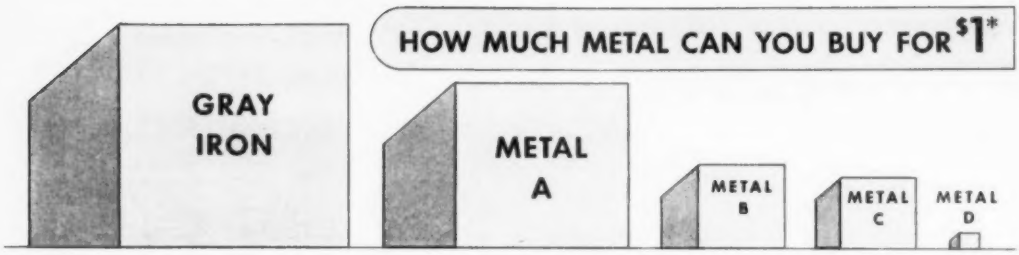
Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

*T.M. Reg. U. S. Pat. Off.



ECONOMY is one of 11 reasons why
GRAY IRON LEADS THE FIELD!

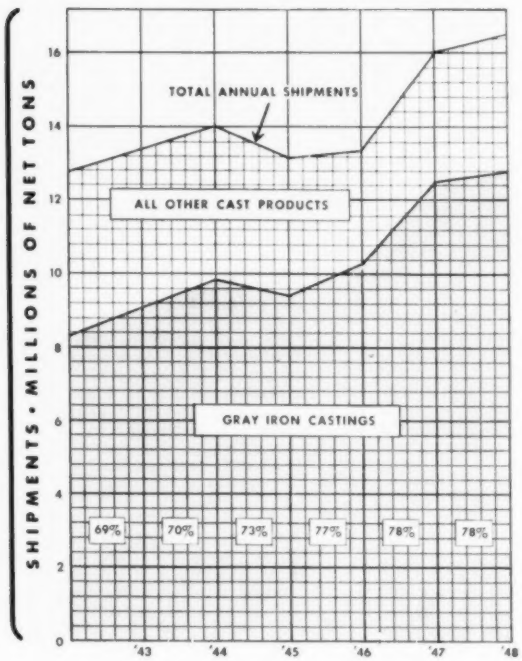


*Chart based on the comparative costs of raw materials (Materials & Methods—Engineering File Facts, Number 156—March, 1948).

Where you need volume *and* weight for stability and rigidity, Gray Iron gives you the greatest economy. You can buy more of it per dollar than any other metal. (See chart above.)*

But ultimate economy is only one of 11 reasons for Gray Iron's increasing popularity. Its other advantageous characteristics include:

- Castability
- Rigidity
- Low Notch Sensitivity
- Wear Resistance
- Heat Resistance
- Corrosion Resistance
- Machinability
- Vibration Absorption
- Durability
- Wide Strength Range

These are the reasons for the steady increase in the use of Gray Iron as against all other cast products. (See chart at left.)

Are you taking full advantage of Gray Iron's unmatched combination of properties in *your* products?

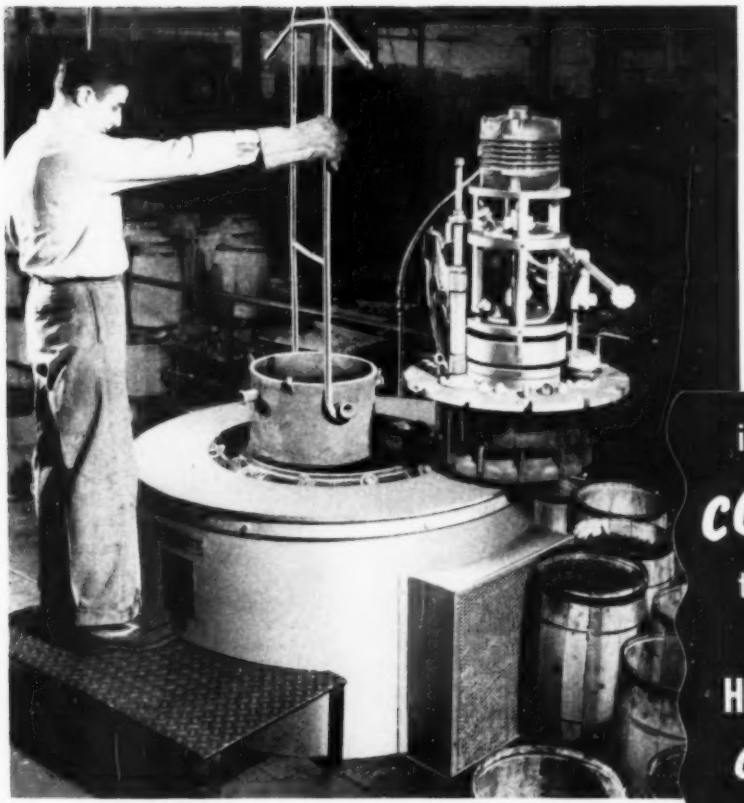
Write for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics, and Details for Designing Cast Components".

Make It Better With Gray Iron

Second largest industry in the metal-working field.

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO



● Type HD-1430 Hevi Duty Vertical Retort Furnace at The Triplex Screw Company, Cleveland, Ohio.

it
COSTS LESS
to Case Harden
with
HEVI DUTY
Carburizing
FURNACES

Accuracy of Control and Uniformity of Electric Heat Enables this Company to *Produce Consistently Precise Results!*

● Here is a typical example of how a nationally known company has had excellent results with their new carburizing installation. Triplex says they have reduced case hardening costs . . . gained better control of heat treating quality. As a result, they have visible savings in heat treating expense, and the more intangible benefits of convenience, speed of production, and higher quality of products. You, too, can produce consistently precise results if you specify Hevi Duty Furnaces. Tell us about your problem . . . we can help you.

SEND FOR BULLETIN HD-646 TODAY!

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY

DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

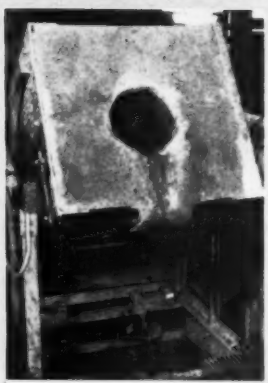
MILWAUKEE 1, WISCONSIN

TAM

Zircon grog type ramming mix

Pouring heat from Allis Chalmers induction furnace at Michiana Products Co.

The same furnace as lined wet with zircon lining.



Furnace ready for relining after 100 heats.

LASTS 4 TO 5 TIMES LONGER

In these 600 lb. capacity Allis Chalmers induction furnaces operated by the Michiana Products Co. of Michigan City, Indiana . . . TAM zircon grog type ramming mix provides excellent lining service. This extended life is realized in melting a variety of alloys ranging from low carbon stainless to heat resisting alloy with nickel contents from 3 to 65% and chrome contents from 8 to 30%.

Resistance to high temperatures and the difficult melting conditions involved is due to the superior characteristics of this lining material. More metal is melted at less cost per ton. That's why it pays to get the full facts on TAM ramming mixes. They may be obtained readily from our field engineers or by addressing your inquiry to our New York office.

TAM PRODUCTS
Registered U. S. Pat. Off.

TAM is a registered trademark

TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

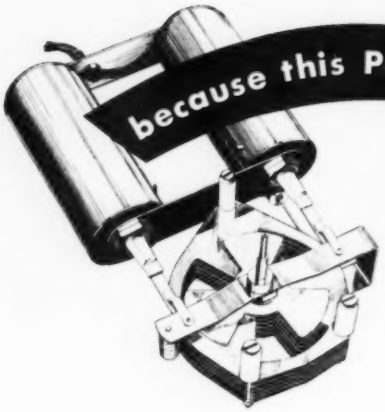
Executive and Sales Office: 111 BROADWAY, NEW YORK CITY · General Offices, Works, and Research Laboratories: NIAGARA FALLS, N.Y.


WARREN
PETROLEUM CORPORATION
TULSA, OKLAHOMA
DISTRICT OFFICES: FORT WORTH • HOUSTON • MIDLAND, TEXAS • DETROIT • MOBILE • NEWARK • MT. VERNON, ILL. • MADISON, WIS.

Look!

FULL SENSITIVITY EVEN ON WIDE SCALES

because this Potentiometer has NO SLIDEWIRE



Here is the heart of Dynalog Instruments . . . the "Dynapoise Drive". Its simple, variable capacitor eliminates the friction and turn-to-turn skips of the conventional slidewire.

With full sensitivity on *wide* scales (as well as narrow ones), Dynalog* Electronic Recorders and Controllers at last make it possible to select chart ranges that cover shutdowns and other process extremes. No longer is it necessary to compromise accuracy in order to get complete chart records of an entire process cycle.

The unique, radio-type capacitor of Dynalog Instruments gives them three times the sensitivity of previous instruments for the same jobs (1/100 of 1% of scale). It provides *absolutely stepless*, continuous balancing, free from turn-to-turn limitations of a slidewire.

This and many other advantages of these electronic potentiometers are results of full and skillful use of electronic methods which eliminate mechanisms found in conventional bridge-type instruments. Dynalog Instruments are available for measuring and controlling temperatures (with thermocouples or resistance bulbs), humidity, pressure, flow, force, etc. Get the complete story in Bulletin 427. Write **The Foxboro Company, 52 Neponset Avenue, Foxboro, Mass., U. S. A.**

DYNALOG* SIMPLICITY that means PRACTICALLY NO MAINTENANCE

• No slidewire • No moving contacts • No high-speed motor • No galvanometer • No standardizing • No gears or cables • No knowledge of electronics needed • Only occasional replacement of standard radio tubes required • Impossible to over-range

*Reg. U. S. Pat. Off.

FOXBORO

Reg. U.S. Pat. Off:

DYNALOG ELECTRONIC INSTRUMENTS

An example of Lenzites trabea—a common mold magnified seventy-four times.

Stop Sacrificing Profits!

Production delays and *costly waits* are the result when bacteria get into lubricants and coolants causing them to go "sour."

You can protect yourself against these profit-eating failures by using Dowicides. Dowicides, Dow's industrial germicides and fungicides, increase the service life of cutting, grinding, rolling, and hydraulic soluble oil emulsions by keeping the bugs out, thus reducing machine "down time." These tested materials, developed by The Dow Chemical Company, are available in both oil and water-soluble types.

Stop sacrificing profits! Investigate Dowicides today. Extensive Dow laboratory facilities are maintained to help you solve your problems. Contact your nearest sales office or write direct.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

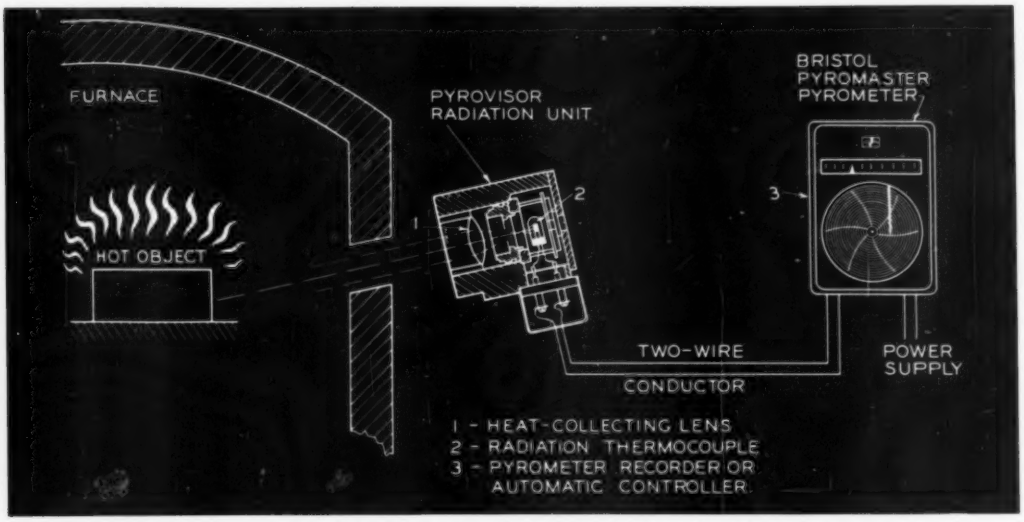
New York • Boston • Philadelphia • Washington
Cleveland • Detroit • Chicago • St. Louis • Houston
San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

use the

Dowicides

Industrial Germicides and Fungicides

DOW



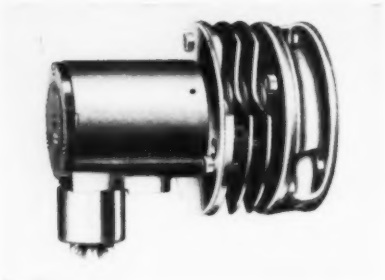
Pyrovisor "eye" mounted outside of hot zone focuses heat rays emitted from hot object onto thermocouple which registers surface temperature values.

NEW! Get Faster Heat Measurements

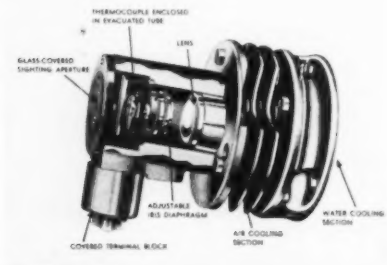
99% response within one second

Save Costly Maintenance

with the eye that "feels" the heat



Bristol Pyrovisor Radiation Pyrometer records and accurately controls temperatures up to 4000 deg. F.



Sensitive element is enclosed in evacuated bulb for protection against deterioration and to prevent shifts in calibration. Tiny mass means extremely small time lag—99% response to change within one second.

No thermocouple can possibly match the speed of response of the **new** Bristol Pyrovisor Radiation Pyrometer.

No thermocouple can be used under such adverse conditions (over 2800 deg. F, inaccessible locations, moving objects) as the Bristol Pyrovisor.

No thermocouple can match the Pyrovisor's record of eliminating replacement and maintenance.

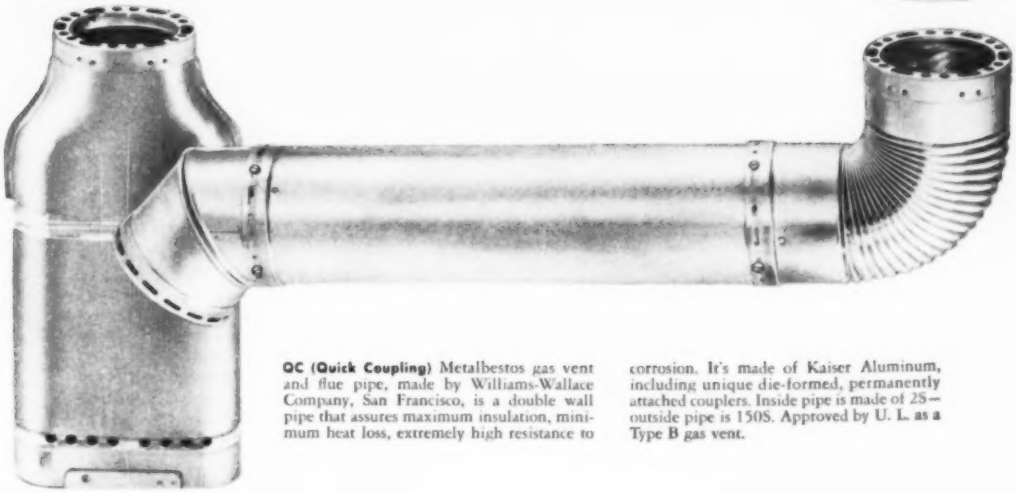
Bristol Pyrovisor gives you more accurate measurement, and responds to temperature changes several times faster than other equipment. It *sights* directly on the hot object . . . and measures temperature *without contact*. Send for new Bulletin P1242. THE BRISTOL COMPANY, 106 Bristol Road, Waterbury 91, Conn. (The Bristol Co. of Canada, Ltd., Toronto, Ont.)

AUTOMATIC
CONTROLLING,
RECORDING
AND
TELEMETERING
INSTRUMENTS

BRISTOL

Gives You the Most from Heat

Another profitable conversion to Kaiser Aluminum 150S



QC (Quick Coupling) Metalbestos gas vent and flue pipe, made by Williams-Wallace Company, San Francisco, is a double wall pipe that assures maximum insulation, minimum heat loss, extremely high resistance to corrosion. It's made of Kaiser Aluminum, including unique die-formed, permanently attached couplers. Inside pipe is made of 2S—outside pipe is 150S. Approved by U. L. as a Type B gas vent.

Originally made of galvanized steel, later made of 52S, the outside wall of QC Metalbestos gas vent pipe is now made of the new Kaiser Aluminum Alloy 150S. Here's why:

Compared to galvanized steel—aluminum is much lighter, far more resistant to corrosive flue gases—and is extremely workable. Cost of the finished article is the same.

Compared to 52S—150S is more workable, too. And though it costs less, it doesn't sacrifice any of Kaiser Aluminum's light weight, freedom from rust and resistance to corrosion.

In addition, the workability and light weight of this remarkable new alloy saves steps in fabricating, handling, storing. Shipping costs are cut.

Customers like the permanent aluminum-bright finish of Metalbestos gas vent pipe—workers like the ease with which they can install it.

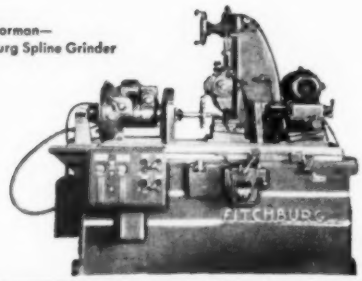
We'll gladly show you how 150S can benefit your operation—and show you other examples of profitable conversions to this new Kaiser Aluminum alloy.

Kaiser Aluminum is produced by Kaiser Aluminum & Chemical Corporation.

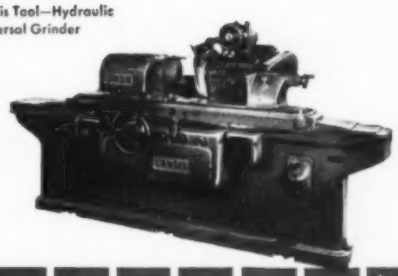
Kaiser Aluminum

SOLD BY KAISER ALUMINUM & CHEMICAL SALES, INC., KAISER BUILDING, OAKLAND 12, CALIFORNIA . . . OFFICES IN: Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Kansas City • Los Angeles Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Portland, Ore., • Rochester, N. Y. • Seattle • Spokane • St. Louis Wichita • EXPORT OFFICE, OAKLAND, CALIFORNIA • WAREHOUSE DISTRIBUTORS IN PRINCIPAL CITIES

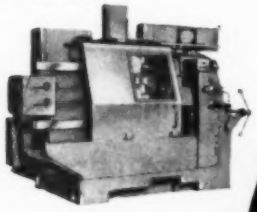
Van Norman—
Fitchburg Spline Grinder



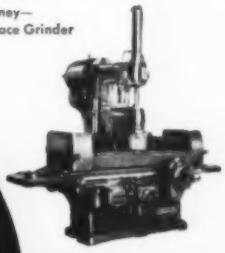
Landis Tool—Hydraulic
Universal Grinder



Bullard—
Man-Au-Trol Horizontal Lathe

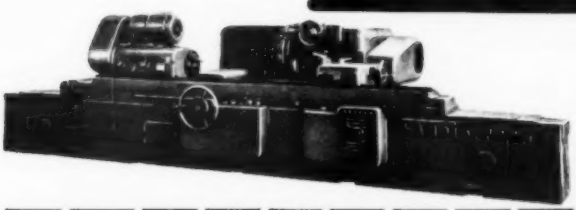


Pratt & Whitney—
Vertical Surface Grinder



Your New Equipment Deserves Only The Best Lubrication

Landis Tool—
Hydraulic Cylindrical Grinder



Van Norman—
Fitchburg Special
Plunge-Cut Grinder

Get Skilled Cities Service Lubrication From the Start

More than *14 billions* of *dollars* will be spent on new plants and new equipment in 1949. The smartest investment you can make for the maintenance and protection of your new equipment is to begin with a sound lubrication program.

In setting up lubrication schedules for new equipment why not first investigate the advantages to be gained by using Cities Service fine quality petroleum products. Whatever the make and model of machine you'll find the right lubricant to meet your particular requirements. Moreover, an experienced Cities Service Lubrication Engineer will be on hand to provide sound recommendations on any kind of lubrication problem. You will find him especially well-informed on the lubrication requirements of the latest types of metal working machinery.

FREE...
This New Fact-Filled Booklet For The Metal Machining Industry

● Cities Service Oil Company,
Sixty Wall Tower, Room 523,
New York 5, N. Y.

Please send me without obligation your new booklet on "Metal Cutting Fluids."

NAME _____

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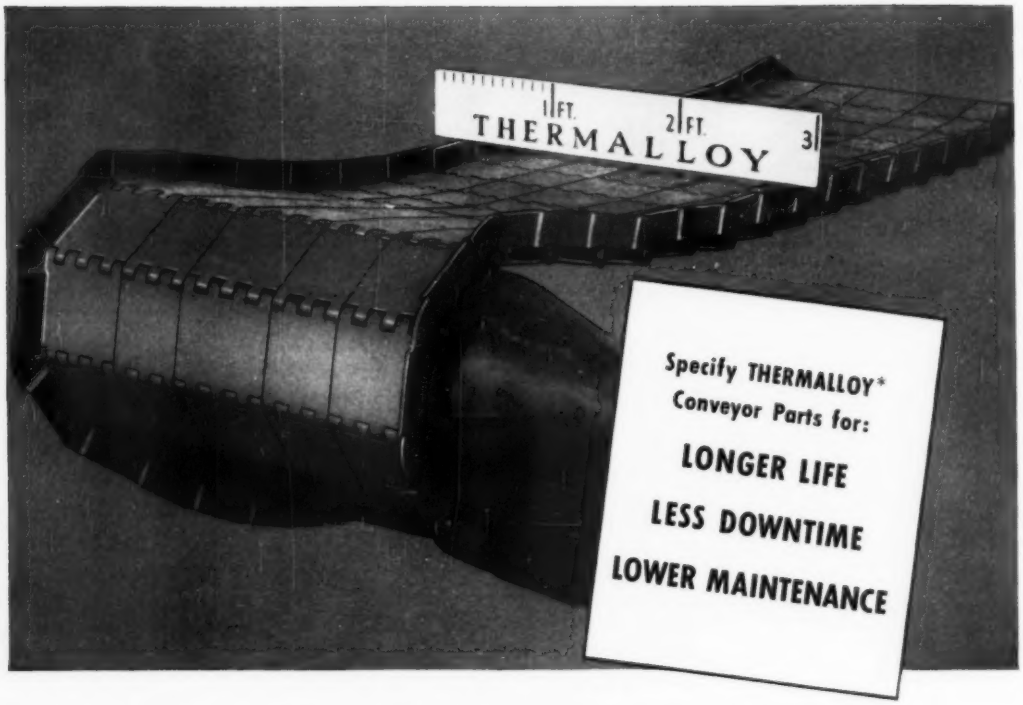
CITY _____ STATE _____

CITIES SERVICE



Looking For An Answer to Heat-Treat

CONVEYOR TROUBLES?

If you're bothered by these conveyor troubles:

- *Jumping the sprockets*
- *Pins "crank-shafting"*
- *Frequent replacement of defective links*
- *High maintenance cost*

. . . you'll find such troubles can usually be traced to improper engineering or inspection of the original conveyor parts.

For example, if dimensions on individual castings are not accurate, the driving drum or sprocket will exert an unequal pull on each line of links. This causes stretching. Pins often "crank-shaft". . . causing belt to "ride" on top of driving drum lugs, instead of engaging properly. This results in fracture of individual links and increased maintenance costs.

The cure for such troubles rests on careful engineering and production. Individual castings must be identical in length—so the belt will engage properly with driving drum, and no one link will be overstressed. Good design also provides close spacing between links for carrying small parts . . . and allows sufficient clearance to eliminate excessive wear.

Electro-Alloys has made a specialty of the precision engineering and production techniques required to produce conveyor belts of outstanding quality. We can show you *proof* that THERMALLOY high alloy conveyor parts give longer life, cut downtime and maintenance costs.

Call your nearest Electro-Alloys engineer. Or write Electro-Alloys Division, 1979 Taylor Street, Elyria, Ohio.

THERMALLOY resists temperatures up to 2200° F.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

"Only Magnesium-Light is light enough"

You'll hear this said often about Dow

MAGNESIUM

the world's lightest structural metal!

With the value of lightness emphasized by constantly rising costs, operators in the motor transport field want more than just lightweight equipment—they want equipment that is *magnesium-light*. These men who use everything from small panel trucks to huge trailers know that only with magnesium can maximum lightness be achieved.

Magnesium is strong and durable and yet is a full one-third lighter than any other structural metal. This bonus—this premium of one-third greater lightness—makes possible significant weight savings which are immediately reflected in increased payload and decreased operating and maintenance costs. A properly designed magnesium body is frequently 20-25% lighter than the same size body built with other light metals.

This is just one of the fields where magnesium increases efficiency by cutting dead weight to a minimum. It will pay you to investigate magnesium lightness when designing your product. For case studies on successful uses of magnesium, send for "How Magnesium Pays."

Get maximum weight reduction—
Use Magnesium Extrusions

Magnesium extrusions can give you significant weight reductions without the loss of needed strength and rigidity. Often, the use of magnesium extrusions tailored to your particular needs will cut manufacturing costs by eliminating the necessity of forming or fabricating from standard shapes. They are competitively priced and available in rods, bars, and tubes as well as structural shapes conforming closely to American Standard Sections.

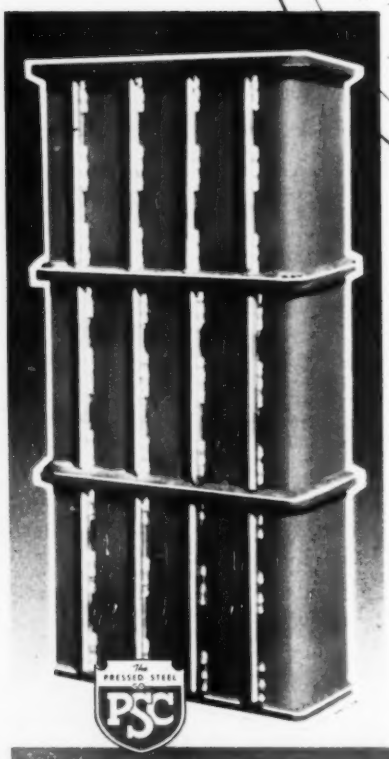
Lighter Products Sell—make your product Magnesium Light!

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston
San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

DOW
DOWMETAL

THESE BOXES
Shortened Furnace Cycle
5 HOURS



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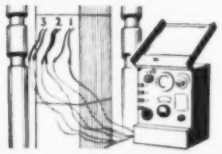

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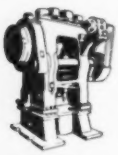

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It has provided—for the first time—an accurate picture of actual stress distribution in such structural, equipment and machine parts as an airplane wing in flight . . . the interior of a mammoth masonry dam . . . the barrel of a cannon when the shell flashes from breech to muzzle . . . the frame of a punch press . . . the connecting rods of diesel engines during operation. In every instance, the new knowledge it revealed has permitted engineers to better the design job.

The long list of successful uses does not define the ultimate applications of the Baldwin SR-4 strain gage, but merely indicates its almost limitless possibilities. If you have any problem where unexplainable failures of parts are puzzling you . . . where some equipment must be lightened while retaining balanced strength . . . where a complete report of actual stress distribution in a structure will aid you in design . . . the Baldwin SR-4 can undoubtedly help you, as it has helped many others.

A comprehensive line of indicating, recording and switching instruments and equipment is available for both laboratory and field studies. The units illustrated include an SR-4 Strain Recorder Chart, and SR-4 Portable Strain Indicator, and an SR-4 Switching Unit, with which 48 strain gages can be switched in and out of service in as little as 50 seconds. These are only a few of many.

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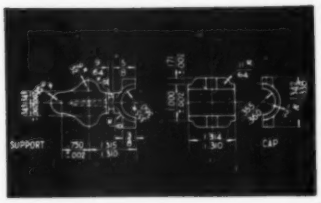

Part:
BRACKET SUPPORT AND CAP (AIRCRAFT)

Alloy: Miscrome 1
Weight: 5.2 oz.
(A.I.S.I. Type 420 Nominal)

Both parts of this actuator assembly are precision-cast to close tolerances. The use of this process eliminated forging die expenses, and resulted in great reduction of machining cost.

Part:
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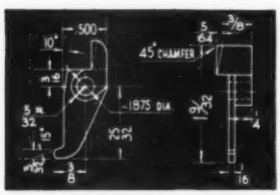

Part:
ROTOR WINDING PICK-UP FINGER

Alloy: Miscrome 5
Weight: .24 oz.
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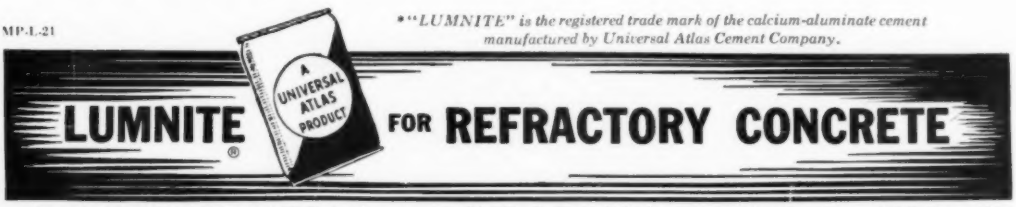

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Camera crew on location filming the electric-furnace sequence for industrial motion picture, "Alloy Steels"

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December, 1949

Volume 56, No. 6

Metal Progress

Ernest E. Thum, Editor

Taylor Lyman, Associate Editor

The cover is an artist's conception (Mr. Arthur Murowsky is not a crystallographer or a metallurgist) of the way a cubic crystal should form. It makes a design with a flavor of the Christmas season.

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Prevention of Stress Corrosion Cracking in Service*

By Edgar H. Dix, Jr.
Assistant Director of Research
Aluminum Research Laboratories
New Kensington, Pa.

THE SPEAKER has chosen to discuss the development and successful commercial production of the aluminum-zinc-magnesium alloys for three reasons. First, these alloys are the most complex and metallurgically intriguing of all of the aluminum alloys. Second, the reason for the difficulties encountered during nearly a quarter of a century before their successful utilization is fraught with lessons from which all metallurgists can profit regardless of their metallurgical interests. Third, the final development is illustrative of what can be accomplished by industrial research, well correlated with production and proper liaison with the consuming industry.

The early alloys of the Al-Zn-Mg type were very susceptible to stress corrosion cracking which prevented their use, and the urgent need for their high strength had not yet developed.

Stress corrosion cracking is the spontaneous cracking, which may occur in some alloys of almost any metal base, under the simultaneous action of prolonged high surface tensile stresses and corrosive environments. Such cracking in brass articles containing high residual stress has been known for many years. All the uninhibited high-strength ternary Al-Zn-Mg alloys are very prone to stress corrosion cracking. Because of this susceptibility, great emphasis has been placed on improving the resistance to stress corrosion cracking, in the efforts to produce structurally useful alloys of this type.

General Theory — Although an extensive literature on stress corrosion cracking has been developed in recent years, agreement among the various investigators as to the mechanism of this phenomenon is confined to a few fundamental principles. Two basic points on which there is agreement are: *(a)* A high enduring tensile stress must exist at the surface, whose minimum value varies considerably with the alloy and its environment. *(b)* A corrosive influence must be present, whose nature also varies with the alloy. With some very susceptible alloys, even a minute amount of moisture seems to be sufficient.

Basically, then, stress corrosion cracking is caused by the combined effects of a high enduring tensile stress at the surface and corrosive attack. It is generally agreed that in some way the corrosion attack initiates small fissures principally in a direction generally perpendicular to the tensile stress. These tiny fissures cause a stress concentration at their base. This increased stress causes the fissures to open further, thus exposing fresh metal to corrosive attack. Finally, failure occurs by these mutually accelerating effects.

[The lecturer then outlined the electrochemical theory he and his associates have formulated about the location of the path of fracture. A major portion of the lecture is devoted to the application of this theory to the observed facts about 75S, the newest of the strong, wrought aluminum alloys. In the small space available in *Metal Progress*, attention will be confined to certain engineering considerations. The complete text will be published in the next volume of *Transactions* of the ⊖.]

Engineering Significance

In the foregoing discussion, the phrase "susceptibility to stress corrosion cracking" has been used frequently. It will be desirable to explain the significance intended by the speaker. It is intended to imply a condition in the microstructure

*From the introductory portion of the 24th Edward de Mille Campbell Memorial Lecture, "The Aluminum-Zinc-Magnesium Alloys — Their Development and Commercial Production".

of an alloy such that in corroding solutions of accelerated tests, of natural environments, or of service conditions, selective corrosion occurs along continuous paths and is accelerated by a high enduring tensile stress. The "enduring tensile stress" in the majority of the testing procedures employed by the Aluminum Research Laboratories is a stress equal to 75% of the tensile yield strength of the specific product being tested.

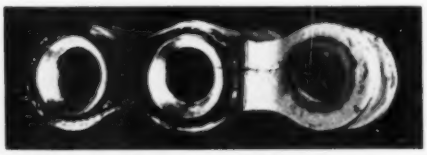
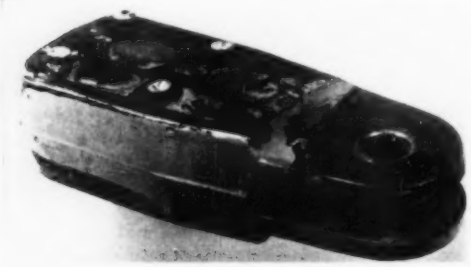


Fig. 1 — (Top) Stress Corrosion Crack Between Pressed-In Insert and Rivet Hole in Strut Fitting Made From an Extruded Shape, and (Below) Same Fitting Redesigned as a Forging. Natural size



While it is relatively easy to determine if a product is "susceptible to stress corrosion cracking", it is far more difficult to determine if it possesses a "*degree* of susceptibility" which will hamper its general usefulness.

To answer this question, it has been found most helpful to compare any new alloy, under conditions in which it is expected to be used, with other commercial aluminum alloys which have had a long satisfactory service record. Such comparisons can be made only on a statistical basis and hence require a large amount of testing. The testing methods used in the Aluminum Research Laboratories have been fully described in a paper contributed to the A.S.T.M.-A.I.M.E. symposium on stress corrosion (1944). They are severe and varied. Some of the aluminum alloy products which have been long and successfully used are "susceptible to stress corrosion cracking" as just defined. However, their degree of susceptibility is so low that when properly engineered, they are, in a practical sense, free from stress corrosion cracking. In Alcoa 75S the aluminum-zinc-magnesium alloys *have attained this satisfactory degree of resistance to stress corrosion cracking.*

As an aid to a better understanding of the practical significance of the preceding discussion, it will be helpful to describe several instances of stress corrosion cracking of high-strength aluminum alloy products which have occurred in service and which were readily corrected without changing their "degree of susceptibility to stress corrosion cracking" within the limits of the speaker's definition. The three examples to be cited are representative of the types of situations in which stress corrosion cracking of these alloys has been experienced in service. High residual tensile stresses, easily avoidable, were induced by three general conditions: *(a)* Assembly methods. *(b)* Metal working procedures during fabrication of the alloy product. *(c)* Quenching. (Rapid quenching of aluminum alloys induces compressive stresses in the surface layers which are favorable. However, subsequent removal of metal from the central portion will expose surface layers having high residual tensile stresses.)

The speaker does not know of any stress corrosion failures of commercial aluminum alloy parts which were caused solely by operating stresses for which the part was designed. This happy situation undoubtedly exists because design considerations, including the usual "factor of safety", deflection and fatigue considerations, limit the working stress to a value below that required to produce stress corrosion cracking in the commercially used aluminum alloys.

Assembly Methods — As an example of improper assembly methods, let us consider an incident of stress corrosion cracking which occurred in strut end fittings containing pressed-in steel inserts used in a prewar type of plane. In the original design illustrated in the top photograph of Fig. 1, the fittings were made from 24S-T4 extrusions. By sawing pieces from the extrusion, these fittings could be produced very economically. Two of the holes in the fitting were for large rivets fastening the fittings to the strut end, while a third hole was bushed with a pressed-in steel insert to receive a bolt for attaching the folding wing to the fuselage.

After a comparatively short service, cracks were found in some of the fittings, sometimes following a path between the holes, as may be seen in the illustration, and sometimes extending radially from the surface in contact with the pressed-in bushing. To eliminate this cracking, new fittings were designed as forgings employing nearly twice the bulk of metal, as illustrated in

the bottom photograph of Fig. 1. (Both photographs are to the same scale.) Four small diameter rivets were used instead of the two large rivets. The pressed-in steel bushings, however, were still retained and stress corrosion cracks continued to occur in service, progressing radially from the pressed-in bushing.

This change in product and design was made prior to our examination of the failed fittings. Metallographic examination of these fittings enabled us to diagnose the cracking as being caused by stress corrosion resulting from the high residual stresses produced by over-driven large rivets and pressed-in bushings. The cracking had occurred even though the fittings had been thoroughly painted by an approved method.

Extensive laboratory investigation demonstrated that stress corrosion cracking could be completely avoided by more careful control of the interference fit between the outside diameter of the bushing and the inside diameter of the hole in the fitting, together with the elimination of the large rivets. After the practices were changed to conform with this information, these fittings gave satisfactory service.

This early experience led to the adoption of satisfactory tolerance limits on interference fits which, if adhered to, avoided further troubles from stress corrosion cracking resulting from pressed-in bushings.

Fabrication Procedures — In another case, longitudinal cracks appeared in the 24S alloy tubular spar chords on an important type of civilian and military aircraft after about one year of service.* Attempts to produce cracks of this type by mechanical means were completely unsuccessful. Again metallurgical examinations indicated that these cracks were caused by stress corrosion. Identical cracks were produced in similar tubing, without external stressing, by exposure for two weeks in a salt spray test.

The important lessons learned from this experience justify detailed discussion. In the first place, the tubing was produced by a method of manufacture involving cold working after a solution heat treatment in order to increase the strength of the tubing and permit the design of a lighter airplane. To accomplish the cold working, the tubing was solution heat treated while in round cross section, and after room temperature aging, was sunk — that is, drawn without the use of a mandrel — to a square section with rounded corners. It was known that this procedure introduced high residual stress in the tubing but mechanical and structural tests showed that, in a structural sense, it was entirely satisfactory.

When used in the airplane, the tubing was anodized, primed with zinc chromate primer and given a top coat of approved paint pigmented with aluminum powder. In spite of these protective measures, stress corrosion cracks occurred. Subsequent laboratory tests showed that such protective measures will prolong the time required to produce cracks but cannot be depended upon to eliminate stress corrosion cracking.

Another important lesson is the effect of the relationship of direction of tensile stress to grain structure. The residual stress in this tubing was estimated at about 35,000 psi. in the transverse direction and something over twice that amount in the longitudinal direction, yet the stress corrosion cracks occurred in the longitudinal direction produced by the much lower stress.

Since the bloom was produced by extrusion, the grain structure of the tube is elongated in the direction of the length of the tube, which is exactly the path of the crack, as exposed on the surface. In a cross section of the tube through this crack

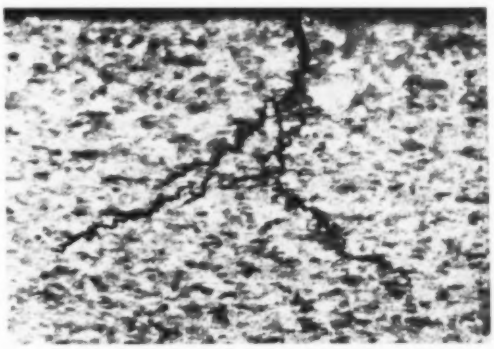


Fig. 2 — Stress Corrosion Crack in Surface of Tubular Spar Chord Is Parallel to Axis of Tube, But in Cross Section It Has a Tendency to Spread, Following the Longer Direction of the Transverse Grain. 20 ×

(Fig. 2), it will be observed that the crack starts perpendicular to the surface and then forks out, tending to follow the longer direction of the transverse grain.

The alloy 24S from which the tubing was made must be rapidly quenched to avoid precipitation along grain boundaries. This tubing was not quenched at a sufficiently rapid rate to avoid precipitation at the grain boundaries and the con-

*Baxter C. Madden, Jr., "Test Methods and Progress in the Stress-Corrosion Investigation at Wright Field", Symposium on Stress Corrosion Cracking of Metals, A.S.T.M.-A.I.M.E., 1944, p. 233.

Fig. 3 — Stress Corrosion Fracture of Shank of Forged Propeller, Caused by High Residual Tensile Stresses in Surface Layers of Bored Hole, Resulting From Stresses Caused by Rapid Quench

sequent susceptibility to stress corrosion cracking along these boundaries. The grain structure, greatly elongated in the longitudinal direction, offered a very direct path for the stress corrosion crack to follow, whereas, if a crack had occurred in the transverse direction, it would have had to follow a much longer and irregular path.

This experience also teaches that in evaluating the degree of susceptibility to stress corrosion cracking of wrought products, specimens must be tested not only in the longitudinal direction (that is, that of maximum metal flow during working) but also in the two transverse directions. Attempts to reduce the residual stress by thermal treatments were unsuccessful. Slow rates of heating to even moderate temperatures produced longitudinal cracks having a similar appearance to the stress corrosion cracks. Even if the cracks had not occurred, a temperature sufficient to cause adequate stress relief would have greatly reduced the strength of the tubing.

It was finally decided that the high residual stresses, coupled with susceptibility to stress corrosion cracking, made this tubing undesirable for commercial use. The specifications were changed and 24S-T4 tubing was used in all later models.

The only difference between this tubing and that previously used was brought about by a change in the sequence of manufacturing operations. In the changed procedure, the tubing was sunk from the round to the square shape *prior* to the solution heat treatment, thus avoiding the high residual stresses caused by sinking *after* the solution heat treatment. Of course, the elimination of the cold reduction after heat treatment lowered the strength of the tubing and hence the permissible design stress, and increased somewhat the weight of the plane. After this change, however, no stress corrosion cracking of the tubing was experienced in thousands of planes of this type used in World War II.

Quenching Rate — An unusual situation in which the machining of a rapidly quenched large diameter forging resulted in a high residual tensile stress will be described in the last example. Stress corrosion cracking was encountered in the early use of Alcoa 76S, an aluminum-zinc-magnesium forging alloy for aircraft propeller blades of high strength and hardness with improved abrasion resistance. The shank of the propeller, about 6 in. in diameter, was forged solid, solution heat treated, and artificially aged. Then a tapered hole about 17 in. in length was bored in the center with the diameter gradually decreasing from about 3 in. at the end of the shank, as illustrated in Fig. 3. The cracks started at the inside surface of the hollow shank and progressed radially and longitudinally. The stress corrosion fracture is indicated by the dotted lines in the figure. (The fracture was completed mechanically in order to examine the surface of the stress corrosion fracture.)

In the thorough investigation which followed (made under the direction of the late L. W. Kempf of our Cleveland Research Division) it was determined that the removal of metal from the center of the shank had exposed layers at the surface of the hole having high residual circumferential tensile stresses resulting from rapid quenching. When the hollow shanks were tested for susceptibility to stress corrosion cracking by exposure to a boiling 6% sodium chloride solution, longitudinal cracks occurred very similar to those which had been experienced in service. Quenching in boiling water, instead of the usual 160° F., reduced the stress level at the surface of the bore so that no stress corrosion cracking occurred in the boiling sodium chloride test.

As an additional precaution, the propeller manufacturer shot peened the surface of the inside of the bore. The shot peening further reduced any possibility of a high surface tensile stress and may have even introduced a compressive stress. After the adoption of the boiling water quench and the shot peening, no stress corrosion cracking was experienced and hundreds of thousands of 76S propeller blades have been in successful service.

Simple Requirements for Satisfactory Performance — The three examples cited show that even with products which exhibit some degree of susceptibility to stress corrosion cracking under service conditions in the presence of a high enduring tensile stress, satisfactory performance can be obtained by merely avoiding the unnecessarily high surface tensile stresses. Let us repeat for emphasis that stresses imposed by necessary service loads, to our knowledge, have not produced stress corrosion cracks in aluminum alloy products which have been used commercially in this country.

What to Do About Russia's Bomb

The People's Part

By Bernard M. Baruch★

NUMEROUS requests have been made for a statement on the reported "atomic explosion" in the Soviet Union and what we should do. Four actions seem vital:

1. That the United States stand its ground in insisting upon nothing less than a truly effective international control of atomic energy, meanwhile welcoming any Soviet proposals which would contribute to that end.

2. Until safe and sure control is obtained, every effort must be pressed to maintain our overwhelming advantage in atomic weapons. We dare not lose any of that advantage — for the sake of peace.

3. Re-examine our strategy for peace-making. Our aims remain unchanged — to resist aggression and to unite the free peoples of the world in common defense for lasting peace. All plans for attaining these aims must now be reviewed.

4. Immediate enactment of a stand-by mobilization plan, including a thorough-going civilian defense. We dare not wait until war has begun and bombs are falling to begin to debate what should be done in the control of prices, wages and rent, the rationing of scarce necessities, priorities, and the civilian defense of our cities.

Merely to "outlaw" the atomic bomb is no insurance against atomic destruction. Unless this prohibition is accompained by a truly effective, enforceable international inspection and control of atomic energy, we would be penalizing those nations which observe agreements to the advantage of those who may not.

For nearly six months after the United States' plan for the international control of atomic energy was presented to the United Nations on June 14, 1946, the American delegation refrained from seeking a vote. More than 70 formal meetings were held to give the highest officials in Russia time to become thoroughly informed of the nature of the problem before coming to their decision. At no time did the Soviets ever propose a safe alternative to the American plan — safe for the whole world.

All future atomic-energy proposals should be submitted to one test: "Do they mean safe and sure control?" Anything less than that would be worse than nothing. It may be we shall have to live with the inability to control atomic energy all our lives. If that is to be our lot, let us face it calmly and resolutely, with wide-open eyes. Let us not blind ourselves with false reassurances or meaningless words labeled "agreement".

No previous President and no previous Congress have faced more difficult problems. The President was wise in informing the people of this "atomic explosion" for it swells the already heavy burden of responsibility every American bears. I have no doubt we shall measure up to this responsibility, if we are told what is expected of us.

★Original U. S. representative on United Nations' committee for the control of atomic energy.

†Chairman, Joint Chiefs of Staff, U.S.A. From address at Akron, Ohio, Oct. 12, 1949.

The Army's Part

By Gen. Omar N. Bradley†

SO LONG as we alone held the atomic weapon, we could be sure that no atomic bomb would start another war. We also have the comforting knowledge that our newly allied friends of the Atlantic Pact will never *start* a war for *any* purpose. This increases the possibility of having no war at all. However, facing all the international facts of life, you realize that there is a large land-based power in the world today that *might* start a war.

However motivated, Russia has maintained an army of 2,500,000 men. Her air force numbers over 600,000 men with about 15,000 aircraft. Adapting German submarine models, she has developed a very modern undersea force. Since VE-Day, she has devoted a large percentage of her industrial capacity to the maintenance and modernization of her armed forces. And two weeks ago, the Soviet Union — the only possible enemy in sight for the next 20 years — threw into the balance its newly revealed possession of the atom bomb.

In this situation, to gain maximum safety at the least expense, the Joint Chiefs of Staff must give very careful consideration to those items which constitute the basic necessities.

First priority must provide those forces which can avert disaster in the event that war is thrust upon us and our friends.

To impress the aggressor that a bully's blow can't escape the sting of reprisal, we must possess the means to retaliate quickly and hard.

And finally, knowing well that blows once exchanged do not subside until one or the other is victor, we must provide the means necessary for the mobilization of our manpower and other resources which can eventually carry the war back to the enemy, to his ultimate defeat.

The Russians could be foolhardy enough to launch an atomic attack with only a handful of atomic bombs, but military men must be realists. We have worked out an orderly timetable of preparations for atomic defense.

Our earlier preparation for the preponderance of might, and the stockpiling of atomic weapons, and the general refurbishing of our armed forces required all of the defense money our economy could stand. Our future timetable calls for spreading out the expenditures in an orderly progression, while our national economy continues to strengthen. For a strong economy is our best resource.

In any attempt to overrun Europe the Army must be ready to repel a land assault. If our pleas for control of atomic energy are *not* met with honest agreement, then the blow may strike at the heart of industrial America. We may have to invest our funds in anti-aircraft guided missiles, necessary radar screen for Canada and the United States and the Arctic, and the necessary fighter intercepter squadrons to dispel long-range bombardment attack. In either situation, our Navy must maintain control of the seas. It possesses that power of control today.

By Roger F. Waindle
General Manager, Industrial Products Division
Elgin National Watch Co., Aurora, Ill.

New Uses for Cobalt-Base Spring Alloy

ABOUT TWO YEARS AGO an announcement was made by metallurgists of Battelle Memorial Institute of an alloy, completely noncorrosive under atmospheric conditions and having excellent "spring properties", which had been developed in the course of a research sponsored by Elgin National Watch Co. Since that time the material, trade named "Elgiloy", has been used with outstanding success for mainsprings in watches, replacing the traditional heat treated high-carbon steel, whose defect has always been that it is susceptible to corrosion fatigue — a defect meaning that the slightest, almost invisible particle of rust will snap the tensed spring.

A watch power-spring has been said to be so highly stressed as to be always "on the verge of a nervous breakdown"! The use of corrosion resistant metal has increased by several times the former slim factor of safety, so that three years of on-the-market experience has verified the original test data. Watch breakdown due to mainspring failure has been reduced from a major consideration to a rarity. As remarked, this is due largely to corrosion resistance. Corrosion resistance is not the only consideration, of course. Just any stainless steel does not provide the answer; a successful spring material must also have that combination of high tensile strength, high range of truly elastic behavior, high endurance limit, freedom from notch sensitivity, and those other factors comprising toughness that are lumped together in the term "good spring properties". Such superior material can obviously be fabricated into a spring of equal size and weight but with considerably higher power output. This opens the way for a spring of higher factor of safety, for a lighter spring, or for a judicious combination of both advantages. In addition, the far greater set resistance (at least three times that of carbon steel mainsprings) and nearly double the fatigue resistance means that the watch-driving strength of this spring is retained several times longer than that of its closest rivals.

In technical terminology these circumstances are summarized in the statements that delivered torque is 115% of an equivalent steel watch spring of highest quality, fatigue resistance is 190% and resistance to set is 370% of steel's. The latter property is vividly shown by Fig. 1 (although the comparison is with stainless steel), wherein wristbands of the same design were stretched to the same extent.

The important characteristics

Fig. 1 — Wristbands of Stainless Steel and Elgiloy Were Stretched an Equal Extent, Ruining the Former, Not Harming the Latter

discussed in the foregoing have made possible entirely new approaches to the design of spring operated devices. This has been particularly true in designs that must operate without modification and with positive dependability in tropical heat and humidity, or in the extreme subzero temperatures of the stratosphere. Really high-temperature operation, too, with satisfactory spring properties still obtained in the plus 750° F. range, has opened new design possibilities where other spring materials have proved inadequate. Many springs, such as those used in toasters, for example, must operate at temperatures too high for ordinary spring steels.

Table I — Typical Physical and Mechanical Properties

PHYSICAL PROPERTIES	
Density	0.300 lb. per cu.in.
Specific gravity	8.3
Linear expansion	12.7×10^{-6} per °C. (0 to 50° C.)
Thermo-elasticity	-39.6×10^{-5} per °C. (0 to 50° C.)
Electrical resistance	600 ohms per circular mil. ft.
Magnetic qualities	Nonmagnetic (see NOTE)
MECHANICAL PROPERTIES, HEAT TREATED FOR WATCH SPRINGS	
Proportional limit	233,000 psi.
Yield strength	280,000 psi.
Ultimate strength	368,000 psi.
Modulus of elasticity	29,500,000 psi.
Rockwell hardness	C-58.5

NOTE — After subjecting to a 2000-gauss field, no residual magnetism was detectable with a 71-gauss sensitivity search coil.

Good high temperature properties would be expected by those at all familiar with recent research in jet engine devices. Nominal chemical composition of Elgiloy is 40% Co, 20% Cr, 15% Ni, 7% Mo, 2.0% Mn, 0.04% Be, 0.15% C and balance iron. Thus the alloy is related to "X-40" (55% Co, 25% Cr, 10% Ni, 7% W), the alloy which has the highest merit rating for gas turbine vanes and blades, with stress-rupture of 10,000 psi. in 1000 hr. at 1800° F. Like X-40, Elgiloy is capable of being forged, rolled and processed by steelmaking practices, somewhat modified.

As rolled, Elgiloy is hard and stiff, but quite capable of being sheared, formed or coiled into ordinary shapes.* Subsequent heat treatment consists of an aging at specified temperatures and times. A desirable and somewhat unique characteristic is, further, that proper aging measurably increases the corrosion resistance to most mediums.

For industrial applications we have found that each part has required its own heat treatment, and it has been necessary for us to work directly with prospective users and devise a heat treatment procedure for the particular application. After this is established it is made available to the customer. Thus the alloy formulated primarily for an improved watch spring is finding many other uses for its unmatched combination of properties. The table of physical properties and the check list illustrate very quickly why this material has been selected for various applications.

While the analysis of the material is basically as given above, it admits of slight modifications for accentuating certain characteristics. For instance, a cutlery grade, hardenable to Rockwell C-62 without loss of its other properties, has been obtained. An everyday application of a special Elgiloy analysis is in the nib of the new Parker "21" fountain pens. Here the combination of very high corrosion resistance and spring properties is teamed up with surprising workability.

Table II — Comparative Corrosion Resistance in 50-Hr. Tests
(Loss in mg. per sq.in. per hr.)

MEDIUM	ELGILOY	18-8 Mo	17% Cr-Fe
Hydrochloric acid			
Concentrated (230° F.)	29.4	639	4166
50% (230° F.)	34.2	679	3355
10% (216° F.)	44.7	38	588
Lactic acid (10%; 219° F.)	Zero	0.002	0.005
Phosphoric acid (10%; 225° F.)	Zero	0.16	0.02
Ferric chloride (10%; 219 °F.)	27.55*	109.43*	202.90*

*These tests run about 10 hr.

Elgiloy can be soldered, welded, brazed; it can be punched and formed in the as-rolled condition, and formed to a limited extent after aging. Springs with end fixtures that once required a punched and riveted joint can now be cheaply and more positively spot welded in assembly.

Table II also points up the remarkable corrosion resistance of this material — exceeding by far the common stainless steels in hydrochloric acid in most concentrations (a most searching test) and in the more commonly encountered, milder mediums. Exposure to the standard salt spray test for 500 hr. has absolutely no effect. In the electrochemical scale Elgiloy is placed between silver and copper.

Naturally many of the industrial and ordnance uses shown in the check list depend on its

*Present size limitations for commercial strip are 2¼ by ⅜ in. max. and 0.010 by 0.003 in. min. For wire: ⅜ in. diameter max., 0.003 in. min.

spring properties. As far as these are related to ultimate strength and Rockwell hardness, one may judge the qualities of the new material from the graphical presentation in Fig. 2 and 3. Properties plotted there are representative values of the various materials heat treated or otherwise processed in the form of flat spring stock.

Generally speaking, the alloy is not "notch sensitive". Notch sensitivity is the reduction in strength caused by stress concentration at notches, burrs or scratches; it is usually expressed as a ratio of the notched to the unnotched strength. Good notch resistance or resistance to surface imperfection is a good measure of a metal's toughness.

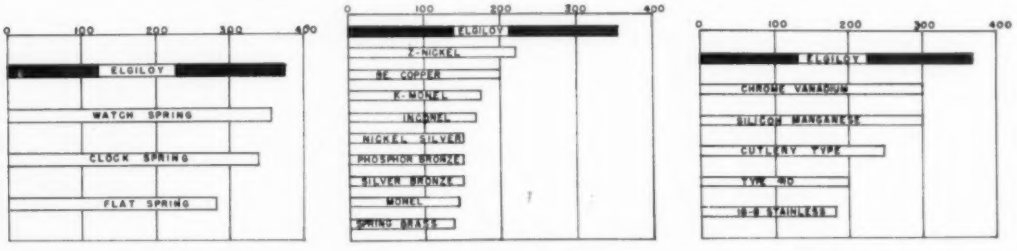
The new alloy is difficult to machine, because it work hardens very quickly in front of the tool. It has been found that carbide tipped tools give the best results, although high speed and high-carbon tools will cut, but the life of the tool is very short. High-carbon or high speed drills are almost no good; carbide tipped drills work fairly well.

Table III — Check List of Performance Requirements of Commercial Applications

Applications	Corrosion Resistance	Fatigue Resistance	Freedom From Set	Elastic Properties	Torque or Strength	Resistance to Abrasion	Operation at Elevated Temp.
Springs							
Firing pin retractor	√	√	√	√	√	√	
Fuses for projectiles	√		√	√	√		
Sewing machines		√	√				
Electric contact springs	√	√	√	√	√		√
For optical equipment	√		√	√			
Movie camera springs	√	√	√	√	√		
Belleville type	√		√	√			
Toaster pop-up mechanisms	√	√	√	√	√		√
Weighing scale draft bands	√	√		√			
Reed (flapper) valves	√	√		√			√
Dental equipment	√	√	√	√			√
Medical sundries	√			√			
Fountain pen nibs	√			√			
Drawing instruments			√	√			
Snap switch components	√	√	√	√	√		
Wrist watch bands	√		√	√			
Traveler rings (weaving)	√					√	
Garment stays	√		√				

In addition to the applications listed in the check list (Table III), Elgiloy is being used or under serious consideration for other difficult specialties. For example, in communication equip-

Fig. 2 (Below) — Ultimate Strength, in Psi. × 10^3, of Flat Spring Stock



High-Carbon Steels | Nonferrous Springs | Alloy Steels

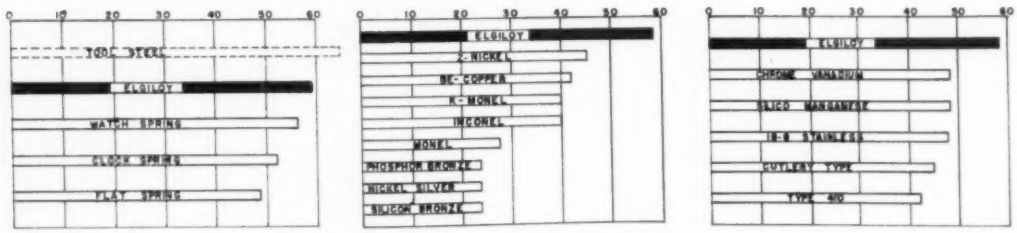


Fig. 3 (Above) — Hardness, Rockwell C

Hardness of Nickel Compacts

By S. R. Williams
Professor of Physics, Emeritus
Amherst College

RECENTLY the Nickel-Cadmium Battery Corp. of Easthampton, Mass., raised the question as to whether the sintered nickel plates, used as one element in its batteries, could be differentiated by means of a hardness test. As a result of our conversations, the battery company furnished for study a series of sintered nickel plates, exposed for different lengths of time to the sintering process. It early became quite apparent that the ordinary hardness tester was not suitable, for the ratio of load to indentation, P/A or P/D, representing a "hardness number", was altogether too small, since A, the area of the indentation, or D, the depth, was too large for the load P applied. The essential factor here is that one must obtain a measurable indentation, but not so large that it extends beyond the area of a component of a microstructure, or its thickness. For many of the indentation hardness testers this can mean only one thing — a control of the load applied.

As the study progressed, some interesting considerations appeared that impinged upon many aspects of the art of hardness testing. These topics will now be outlined, with the hope that they will stimulate some thoughts on the part of metallurgical readers, some of whom may be stimulated to the point of commenting or arguing.

The first question I would like to raise is on nomenclature. What is the difference between a microhardness tester, a macrohardness tester, and a hardness tester? Or is it necessary to make a distinction?

The case for the microhardness tester has been presented by Bergsman in "A Simple, Accurate Microhardness Testing Device", *Metal Progress* for August 1948. (The well-known Knoop indenter is another such machine, described with others in my book "Hardness and Hardness Measurements" published by the ASM.) Bergsman, in a pamphlet describing his machine, writes: "Microhardness testing implies testing the hardness of small specimens, thin foils and wires. Primarily, however, microhardness testing aims at determining the hardness of the different parts and the various components of a microstructure."

It would appear that this is too restricted. We know that a microhardness tester may advantageously be used for testing soft materials. With the ordinary hardness tester of the indenter type, the indentations become excessively and erratically large, and do not give consistent results. When applied to soft materials, does a *micro* become thereby a *macro*hardness tester? Should not our definition for microhardness include, in some way, the latter use of a "microhardness tester"?

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ment, tension and compression springs are used where a constant deflection rate is essential to the successful operation; instrument pivots require corrosion and wear resistance. In medical and dental equipment it is used not only because of its corrosion and elastic properties, but because it does not lose its strength during prolonged or repeated sterilization.

Spring washers in fire fighting and fire protection equipment must resist corrosion 100% in the nozzles of fire extinguishers, and have high set resistance to prevent leakage in these devices. Much the same duty is required in diaphragms of pressure regulators, and in special mechanisms for valves.

These examples give ground for the belief that this new alloy, a proven success in horological applications, will be able to extend the utility of springs into fields of severe duty formerly closed to earlier known alloys, and also enter into many specialties where its unique combination of excellent properties will more than repay the user.

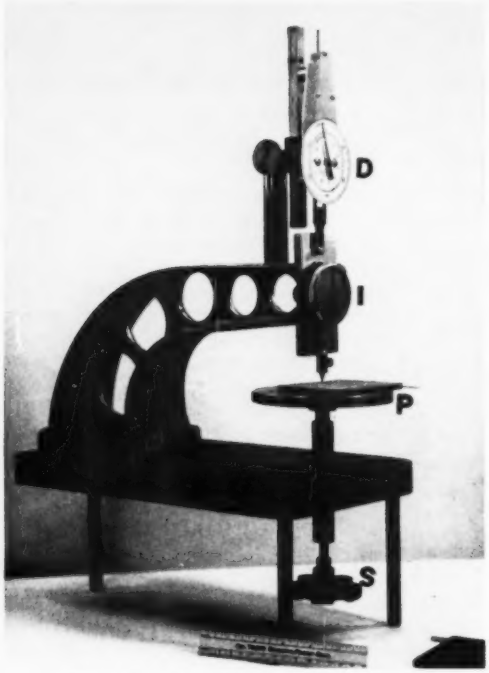


Fig. 1 — A Microhardness Tester Using Dial Indicator I for Depth Gage and Spring Dynamometer D for Loading Device

It appears to the present writer, and it will be brought out in the text below, that a more comprehensive definition and a clear distinction could be made by confining the meaning of "microhardness" tester and tests (at least to testers of the indenter type) to those employing a known relationship between size of indenter and amount of load. As indicated above, the essential factor is a proper sized indentation for measuring either the area or the depth, and this can be done only by controlling the load. A small indenter, such as the Vickers pyramidal indenter, has an angle of 136°. Even if made larger it still has the same angle, so again the *load* is the important factor to control. The Tukon tester, using the Knoop indenter, is set to carry loads between the limits of 0.1 and 3.5 kg. So far as the writer knows, this is a microhardness tester and it carries the largest load of any rated as microhardness machines. Could one establish a dividing line between microhardness and macrohardness indentation testers by saying that those instruments whose loads were above 5 kg. were macrohardness testers and those below were microhardness machines? The Rockwell instrument carries loads as great as 60, 100 and 150 kg., and thus is distinctly a macrohardness tester.

For example, "The Rockwell Superficial Tester is a special purpose machine intended exclusively for hardness tests where only very shallow penetration is possible and where it is desired to know the hardness of the specimen close to the surface." (I quote from Rockwell Catalog Supplement RS-3, p. 2.) Much the same idea applies to the Knoop instrument; both may still be classified as microhardness testers. Even Bergsman in his microhardness tester uses the regular Vickers (136°) pyramid indenter. The principal difference, then, in Bergsman's microhardness tester from the regular Vickers hardness test is the magnitude of the load applied.

Hardness Tester

To return now to the investigation of hardness of a metal powder compact in relation to its sintering history. It will be recalled that a number of nickel battery plates were submitted for study. They varied in sintering time from 3 to 60 min. The 3-min. plates could be scratched with the thumbnail; they were crushed and broken by the ordinary hardness testers. Furthermore, the ball indenter did not give clean-cut indentations in the surface of any of these sintered plates. Various types of indenters were then investigated and the cone indenter was by far the most satisfactory for nickel compacts, in my estimation.

As a result a hardness tester was built using as an indenter the Ludwik cone (90° apex angle on circular cone). The complete machine is shown in Fig. 1. It is a "microhardness tester" in the sense that the load is controlled. The maximum load employed is only 350 g., although it can be fitted with a stronger spring to give larger loads.

By means of the screw S the plate P is raised up against the point of the cone indenter until the hand on the dial indicator I has made one complete turn and is adjusted to zero reading. Due to a small amount of friction and the light spring in the dial indicator, this puts an initial load of about 15 g. on the indenter. The plate P and sample under test are now in firm position under the indenter. By gradually lowering the dynamometer spring D (by rack and pinion on the mast) the bottom of its vertical shaft contacts the top of the vertical shaft in the dial indicator I, and presses the cone indenter into the specimen. Slow and steady motion of the rack and pinion is continued until the scale D registers the value of the desired load, present on the spring. While this is going on, the indenter slowly penetrates the metal by an amount shown on the indicator I, the reciprocal of which is used as the hardness number. This means that this hardness tester uses a constant load and

employs the reciprocal of depth as the hardness number. The constant load adopted was 350 g. The depth of indentation of the steel cone indenter is read to 1/10,000 in. from the dial indicator I, while the load which is applied is read to 0.5 g. from the scale on D. The load (350 g.) which this hardness tester carries puts it definitely in the class we call a "microhardness tester", if we accept the definition suggested at the beginning.

Shape of Indenter

Once the tester had been completed and the nickel plates made by the sintering process had been tested, it became clear that in these plates we had an ideal medium to study the effect of the solid angle of the cone indenter as well as the effect of time in the sintering process. We thus combined an investigation of hardness testing with the "practical" purpose of setting up a criterion for judging the result of a powder metallurgy process.

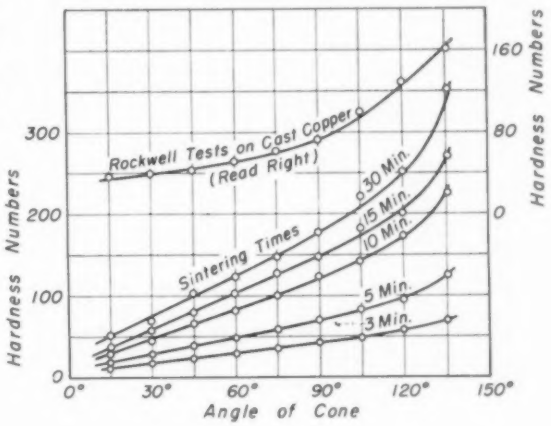
It is obvious that the softer the specimen tested the deeper will be the indentation, other things remaining constant. Hence, to get a number which will go with the degree of hardness, the reciprocal of the depth of indentation was chosen as the hardness number in these comparative tests. Thus, if a certain plate showed a depth of indentation equal to 500 divisions on the indenter scale, this would mean an actual depth of 500/10,000 of an inch, but the hardness number used would be the reciprocal of this, namely, H = 20. The entire scale on the indicator dial I was calibrated, but as noted above the one load of 350 g. was used throughout the observations.

The effect of elasticity of the material on indentation hardness has been widely discussed in the literature. In this series of nickel plates, those sintered 3 min. were extremely soft, quite plastic, and showed little elasticity. The longer the sintering process, however, the more elastic the plates became. The relation between the elasticity and the hardness numbers of the various plates is now under study.

For the time being, the results from various cones are presented. These indenters were merely circular cones of various apex angles,* made of hardened steel, and designed so they could be interchanged with those used on the standard Rockwell hardness tester. Thus there have actually been used on this new instrument the Rockwell indenters, $\frac{1}{16}$-in. ball, the $\frac{1}{8}$-in. ball, the "Brale" indenter, and nine cone indenters ground

*Just what constitutes a "point" on a cone indenter is of considerable interest; study is now being given to this question.

Fig. 2 — Relation Between Hardness Numbers (Reciprocals of Indentation Depth) of Nickel Compacts Sintered Various Times and Angle of Conical Indenter



to as nearly the same degree of polish as possible and having solid angles which ranged from 15° up to 136° by steps of 15°. (The largest value for the solid angle was taken at 136° as this is the angle to which the Vickers pyramid indenter was ground so as to conform as nearly as possible to the $\frac{1}{16}$-in. ball hardness numbers.) Test results are given in Fig. 2, wherein are plotted the reciprocals of the indentation depths for the various conical indenters. A reasonable degree of consistency is shown for the sintered nickel plates.

Hardness Versus Sintering Time

Aside from the general qualitative relationships shown in Fig. 2, there has not yet been established any quantitative relationship between the hardness numbers, as found by the machine of Fig. 1, and the length of sintering. Thus, a change from a sintering time of 45 to 60 min. makes very little difference, while a change from 3 to 5 min. is very large. There is much to be done of a correlative nature before we can hope to make this machine really helpful in distinguishing between the times of sintering.

However, we believe we are on the right track. One reason is given in the topmost curve of Fig. 2, which shows the hardness numbers obtained when the cone indenters were used on the Rockwell instrument, and its lightest load was employed — that is, when both extra weights, 40 and 50 kg., were removed and only the 60 kg. remained. The curve is for cast copper and is of much the same type as those for the sintered plates of nickel.

By Robert H. Duguid, M.D.
Scientific Director
and Col. Wesley C. Cox
Chief
U. S. Army Industrial Hygiene Laboratory
Washington

Cyanide Hazards

MOLTEN cyanide baths are a commonplace to modern metallurgists. Many improved heat treating operations use salt mixtures containing sizable proportions of this material. It is a tribute to the intelligence with which these dangerous substances are handled that their serious potential hazards result in so few accidents. Accidental poisoning or burns are rare, and reports of few cases are to be found in the medical literature. In this regard, past experience with cyanide poisoning in this industry is summed up by Hamilton and Johnstone as follows in their authoritative "Industrial Toxicology" (1945): "They (cyanides) are used in enormous quantities in industry and sometimes with apparent recklessness without any demonstrable harm to the users. Acute poisoning from cyanides does occur, but it is very rare."

This should not be interpreted as indicating that industry tolerates carelessness in these operations; rather, it serves as evidence that any industrial process can be made safe through the application of preventive procedures. Intelligent prevention requires that all individuals who are to work with or around these operations be thoroughly acquainted with the dangers involved and the precautions necessary to avoid poisoning or burns. This can best be accomplished by talks given by the medical and safety departments of the plant. Framed and protected rules for safe practice should be posted.* Methods of first-aid treatment in the event of accident should be included. Foremen should, at about six-month intervals, participate in first-aid demonstrations to prove their proficiency.

This and other remarks in this article refer to poisoning by cyanide rather than to burns by molten salt. Burns should be flushed thoroughly with warm water, then treated as any other burn.

Toxic Action of Cyanides — Cyanides may enter the body through the inhalation of hydrogen cyanide gas, which is one of the most powerful and rapidly acting of all poisons. The gas is also readily absorbed through the skin. Liquid hydrocyanic acid or its salts, either dry or in solution, may enter through the alimentary tract. Salts may enter through abrasions or other skin lesions.

Cyanides ingested into the body act on protoplasm — that substance which is the physical basis of life — and thus arrest the activity of animal and insect life. Apparently the cyanide combines with and destroys those catalysts in the protoplasm that are responsible for the transfer of oxygen from the blood to the tissue cells. Unless the cyanide is removed, death occurs from oxygen starvation of the cells; the oxygen-containing red hemoglobin in the blood cannot perform its work. Hence one characteristic of cyanide poisoning is the bright red color of the venous blood. Instead of its natural dark red color the venous blood acquires the bright red color of the oxygen-rich blood in the arteries leading from the lungs and heart.

The catalysts mentioned above contain both iron and sulphur, and a nonpoisonous dose is destroyed in the body by combining with sulphur to form harmless sulphocyanides. Prior to this they act as powerful stimulants to respiration.

Cyanides are known to be skin irritants, but no such skin troubles have been reported as a result of heat treatment operations.

Health Hazards and Their Control

Handling of Salts — All cyanides and materials containing cyanide should be appropriately labeled and stored separately under lock. Only authorized individuals should have access to the supply. Since cyanide salts and acid react to form hydrogen cyanide, special care should be exercised to prevent any such contact. Cyanide salts should be kept away from nitrates, nitrites or other oxidizing materials with which they react explosively.

Dry cotton gloves should be worn whenever these chemicals are handled. Containers should be opened only in the room in which the salt is to be used, and should be covered at all other

*EDITOR'S NOTE — A 9 x 12-in. poster, "Precautions in Handling Cyanide, With Notes on First Aid", is available from the American Society for Metals, as *Metal Progress* Data Sheet No. 60.

times. A metal scoop should be used, or the cyanide may be dumped as required.

Cyanide should not be handled by anyone with bandaged cuts or skin abrasions. Should direct contact with sound skin occur, thoroughly wash with running water. Food should never be eaten in the vicinity of cyanide operations.

Heat Treating Operations — The principal danger is from burns due to splashing and spattering of the molten material. Splashing is almost always due to carelessness in the handling of parts to be heat treated, in removing scum from the salt bath, and in removing sludge and replenishing the bath. The bath should be covered during melting and solidifying.

Spattering results whenever volatile or reactive materials are introduced into the bath. The steam generated from even small amounts of moisture may violently expel large quantities of the molten salt. Operators should be protected by safety goggles or face masks and they should have asbestos gloves available at all times. Tongs, baskets, and fixtures should be so made that water or oil from the quench will not be carried back to the salt bath. If a spare oven is available, it may well be used to preheat parts to 500 or 600° F. Salt bath furnace equipment should include shields behind which operators may stand while introducing items into the bath.

Cyanides decompose at high temperatures and produce fumes which, if inhaled, are irritating to the mucous membranes of the nasal passages and cause violent sneezing. These fumes are mainly sodium carbonate and are not considered particularly dangerous. However, atmospheric analyses in factories with deficient ventilation have shown hydrogen cyanide around both the salt and the quench baths in significant quantities. Furnaces should therefore be equipped with mechanical exhaust ventilating systems, which should include water spray scrubbers for removing fumes.

Quench baths should also be ventilated to the outside. When a brine is used which contains a caustic, the bath should be equipped with guards for protection against splashes. Quenched parts often retain some of the salts from the molten or quench baths. Rubber gloves should be worn in handling these parts. There is little hazard in the regular cleaning operations, usually with hot water spray. If quenched parts are to be pickled in acid, particular attention should be given to removing salt from deep recesses in the work, lest some hydrogen cyanide gas be produced.

Individuals who may be exposed to the cyanide salts during maintenance of the equipment should be furnished with protective equipment, including approved respirators when required.

Symptoms and Treatment of Cyanide Poisoning

Following large doses of cyanide, asphyxia is instantaneous; the pupils dilate, consciousness is lost, the patient pants laboriously. In the asphyxia stage there is temporary suspension of respiration, slow heart action, the skin is flushed — even "black and blue". This is followed by fall in temperature and death within a few hours. With smaller doses dizziness and headache occur, accompanied by constriction and dryness of the throat, palpitation, and vomiting. Later, a fall in the pulse, chilly sensations, sweating, convulsions and loss of consciousness appear.

In cases of poisoning, the quick action of cyanides often results in death, particularly if no treatment is started prior to the physician's arrival. *Immediate* first aid is necessary if life is to be saved. It is therefore essential that certain medical supplies be in a wall cabinet near the furnaces wherever cyanides are used, as follows:

A carton of amyl nitrite pearls,
Two pint bottles of sodium thiosulphate (1% solution).

In addition, the plant hospital should have available oxygen for inhalation and a kit containing the following for the doctor's use:

Two 10-cu.cm. ampoules of sodium nitrite (3% solution).
Two 50-cu.cm. ampoules of sodium thiosulphate (50% solution).
Two 10-cu.cm. and two 50-cu.cm. sterile syringes.
Two sterile intravenous needles.
One tourniquet.

Emergency Treatment — A physician should be called immediately and first-aid treatment should be started *without delay*. Send for the oxygen and inhalation equipment. The victim should be kept warm and not be moved until the physician arrives.

If the patient is conscious and breathing, have him breathe the contents of one amyl nitrite pearl, breaking it in gauze or a handkerchief which is then held lightly over the nose. If the patient has swallowed cyanide, have him drink a pint of the thiosulphate solution to produce vomiting. The emetic should be repeated every 15 min. until the physician arrives, but only if the patient is conscious. If the patient is unconscious and breathing, administer the contents of one amyl nitrite pearl in the manner described above and give inhalations of oxygen. Do not attempt to force anything down his mouth.

If the patient is not breathing, begin artificial respiration immediately and have an assistant break a pearl of amyl nitrite in a cloth and hold it close to the patient's mouth and nose.

Do not give up until the doctor arrives and takes charge.

Reported by John C. Fisher
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A.S.M. Seminar on Thermodynamics in Physical Metallurgy

On the first two days of the thirty-first National Metal Congress, in Cleveland, five hundred people gathered to hear fifteen invited papers presented at the ⊕ Seminar on Thermodynamics in Physical Metallurgy. The papers dealt with many subjects, ranging from broad philosophical questions regarding the foundations of thermodynamics to specialized applications of thermodynamic principles to particular metallurgical problems. So much material was presented in so short a time that many of those present found it difficult to absorb and retain more than the high points. As in other ⊕ seminars, full comprehension of all the material presented will require careful reading of the published version, to appear later. Nevertheless, in anticipation of the printed volume, it is stimulating to review some of the highlights of the oral presentations.

The opening paper of the seminar was delivered by P. W. Bridgman of Harvard University, winner of a Nobel Prize in physics and an outstanding contributor to the science of thermodynamics. Professor Bridgman is a proponent of the operational viewpoint, according to which a law of nature that cannot be verified by measurement is inadequate. He discussed the laws of thermodynamics from this viewpoint.

With regard to the first law, he pointed out that its formulation is not completely general; sliding friction, fluid flow, and other irreversible processes cannot be adequately treated unless the boundary of the system for which the equation $dE = dQ - dW$ is presumed to hold is chosen with care. In the sliding friction problem, for example, it is essential that the boundary of the system be taken elsewhere than at the interface where the friction occurs.

The applicability of the second law of thermodynamics to mechanisms containing ratchets was questioned. Even though a machine with a ratchet may have the efficiency of a reversible heat engine, it is itself essentially irreversible. Bridgman suggests that "returnability" rather than "reversibility" might be a better criterion to employ in thermodynamic proofs. The existence of Brownian motion demonstrates that small regions do not have a definite temperature, and poses a question concerning the possibility of ratchet mechanisms in molecular systems. Thus, Bridgman believes that the problem associated with "Maxwell's demon" has not been disposed of satisfactorily. His listeners were left with the impression that, in his viewpoint, the statements of the laws of thermodynamics are incomplete and perhaps inadequate. They had the feeling that if some day someone devises a mechanical Maxwell's demon incorporating a ratchet, and with it produces perpetual motion on a commercially profitable scale, Bridgman would be surprised but not shocked.

Opposing viewpoints regarding the most fruitful tools for attacking thermodynamic problems were presented by Clarence Zener, University of Chicago, and L. S. Darken, U. S. Steel Corp. Zener contended that the concepts of statistical mechanics are the most valuable tools for studying thermodynamics, for one can estimate thermodynamic properties and predict their temperature variation by assuming a detailed atomic mechanism, and one can estimate the rate at which a system approaches equilibrium. According to his viewpoint, the statistical method leads to an intuitive feeling for physical phenomena. Darken, on the other hand, contended that the classical con-

cept, independent of assumed atomic mechanisms, is the more valuable, for it has led to precise measurement of thermodynamic properties and to an understanding of complex heterogeneous equilibriums.

Several studies of equilibrium, conducted along the lines of classical thermodynamics, were presented. F. J. Dunkerley, University of Pennsylvania, discussed the application of electromotive force measurements to the determination of phase equilibriums. He described in detail a number of experimental arrangements, and discussed data obtained from several such arrangements. He expressed the view that electromotive force measurements are an extremely valuable aid to the determination of equilibrium diagrams.

John Chipman, Massachusetts Institute of Technology, and J. F. Elliott, U. S. Steel Corp., discussed thermodynamics of liquid solutions. Chipman described a number of methods for measuring the vapor pressures of the several components of a complex liquid solution, leading to a determination of the thermodynamic activities of the various components. In addition to vapor pressure methods, he discussed equilibrium diagram and electromotive force methods. Elliott described a method whereby complete thermodynamic information concerning a ternary system can be calculated when the activity of one component of the system is known, provided that certain other information is available.

A. W. Lawson, University of Chicago, discussed equilibrium diagrams from a theoretical viewpoint. He suggested that it is possible to deal with the free energy expression for binary alloys in a manner somewhat similar to that employed by Van der Waals for the vapor-liquid transformation. He showed that certain simple assumptions regarding the free energy expression for a binary alloy allow equilibrium diagrams of all types to be constructed. In order to change from one type of equilibrium diagram to another, it is necessary only to alter slightly the two arbitrary parameters appearing in his expression for the free energy.

Several broad reviews of important metallurgical phenomena were presented in the seminar. C. W. Birchenall, Carnegie Institute of Technology, reviewed the physical factors affecting order. Short-range and long-range order were discussed, as were the several theories of ordering that have been proposed. F. Seitz, University of Illinois, discussed the mechanism of diffusion in solids. He emphasized the role of lattice vacancies in the diffusion process, and was able to interpret the majority of diffusion phenomena in terms of the lattice vacancy mechanism. J. H. Hollomon, General Electric Research Laboratory, discussed the problem of nucleation. He emphasized the importance of heterogeneous nucleation to all industrial processes involving phase changes. Heterogeneous nucleation refers to the nucleation of new phases on the surfaces of impurity particles present in the parent phase, and is opposed to homogeneous nucleation, which refers to the formation of nuclei in uncontaminated regions of the parent phase. As an example of heterogeneous nucleation, Hollomon mentioned the "seeding" of supercooled clouds with fine particles of silver iodide; this seeding operation causes snow to form at temperatures far above the temperature of spontaneous freezing.

In addition to the papers on diffusion and nucleation, several other contributions dealt with phase change or transformation, rather than with equilibrium phenomena.

Opposing views of the mechanism of the austenite-to-martensite transformation were presented. Morris Cohen, Massachusetts Institute of Technology, in his paper discussing martensite, described a qualitative theory of the martensite transformation. The essential point of the theory is that martensite forms by nucleation and shear. Nuclei, which may be associated with dislocations, are retained from the austenitizing temperature, and at a sufficiently low temperature are used up, one at a time, each nucleating a martensite plate. Formation of each martensite plate is associated with the propagation of a shear wave across an austenite crystal of sufficient size that the final martensite plate corresponds to a net free energy decrease. According to this viewpoint, the speed of formation of martensite plates is not decreased by lowering the temperature, and martensite should form with extreme rapidity at very low temperatures.

On the other hand, J. C. Fisher, General Electric Research Laboratory, contended that the speed of the martensite transformation is retarded at very low temperatures, decreasing to zero at the absolute zero, rather than continuing undiminished as would the speed of an elastic disturbance. He described the martensite transformation as one that proceeds by nucleation and growth, and expressed the viewpoint that the martensite growth process corresponds to the motion of a definite martensite-austenite interface. He also reviewed several theories of the formation of pearlite and bainite during the decomposition of austenite at subcritical temperature.

Charles Wert, University of Chicago, discussed the precipitation of iron carbide and iron nitride in iron at temperatures near room temperature. He pointed out that the mechanical damping of

iron at certain temperatures and vibrational frequencies is proportional to the amount of carbon or nitrogen in solution. As precipitation occurs, the quantity of carbon or nitrogen in solution decreases, and the amount of decrease can be determined quantitatively from the reduced damping. In this manner, the kinetics of the precipitation process can be followed. It was shown that cementite particles grow with a volume proportional to the 3/2 power of the time, whereas iron nitride particles grow with a volume proportional to the 5/2 power of the time. It was concluded that cementite particles grow as spheres and that nitride particles grow as plates. The nuclei were assumed to be present immediately after quenching to the transformation temperature. It does not seem possible to verify this conclusion microscopically, for the maximum particle sizes corresponding to precipitation near room temperature are extremely small.

The damping measurements employed to study precipitation afford also a means for determining the coefficients for diffusion of carbon and nitrogen in ferrite. Measurement of the diffusion coefficients of carbon from room temperature to temperatures near 200° C. leads to a variation of diffusion coefficient with temperature that extrapolates very well to the high-temperature measurements of other investigators. The diffusion coefficient for carbon diffusing in alpha iron now is known experimentally for temperatures between room temperature and 800° C., in which range the diffusion coefficient changes by about ten powers of ten.

Lieuwe Dijkstra, University of Chicago, discussed the nucleation of reversed-direction domains in a ferromagnetic material. According to the domain theory of ferromagnetism, a completely magnetized ferromagnetic specimen consists of a single domain. Upon application of a magnetic field in the direction opposed to the spontaneous magnetization of the single domain, magnetization in the opposite direction can occur only by formation of a new, oppositely oriented domain. Earlier application of nucleation theory to the problem of forming reverse-direction domains has led to predicted values of the coercive force exceeding the measured values by factors as large as 10,000.

Dijkstra suggested that the nucleation process is quite different from that previously proposed, involving, effectively, the rotation of a large and variable volume of spins through an angle of 180°. His predictions of the magnitude of the coercive force are in good agreement with observations for materials of low coercivity.

David Turnbull, General Electric Research Laboratory, discussed the principles governing solidification. He described new experiments in which liquids have been subcooled below their normal melting temperature by a significant fraction of their absolute melting temperatures. For most metals studied, the maximum subcooling was of the order of 20% of the absolute melting temperature. The remarkable amount of undercooling obtained was associated with the technique of measurement, wherein the liquids studied were broken up into small droplets. In large masses of liquid, solidification normally is nucleated by the impurities that are invariably present. But when these impurities are isolated in a small fraction of the droplets, the majority of the droplets are free from impurity particles, and can subcool to the temperature of spontaneous homogeneous nucleation of the solid.

From the observed maximum subcooling and the theory of nucleation, Turnbull deduced the interfacial free energies (interfacial tensions) between solid and liquid metals. He observed that the interfacial tensions found in this way were proportional to the latent heats of fusion of the metals under consideration.

The final paper of the seminar was given by J. B. Austin, U. S. Steel Corp. He discussed the role of thermodynamics in metallurgical research and reviewed the importance of thermodynamics to industry. He pointed out that many thermodynamic investigations conducted in the laboratory on a small scale have led to information and predictions that apply successfully to large-scale industrial practice. Certainly, it is better to determine the answer to a particular industrial problem by means of a well-established thermodynamic theory and carefully controlled laboratory experiment, than to answer each industrial question individually by checking proposed processes with full-scale equipment.

The ⊖ Seminar on Thermodynamics in Metallurgy presents a challenge to metallurgists. There are two important groups of questions that can be answered by thermodynamics. The first concerns equilibrium and the products of transformation, and to these questions classical thermodynamics is able to answer yes or no, and to state how much. Questions in the second group relate to the rates and mechanisms of change and transformation, and are best answered by statistical mechanics, which gives valuable insight into mechanisms and accurate estimates of rates.

In the opinions of the contributors to the seminar, widespread use of the principles of thermodynamics, employing both classical and statistical methods, is essential for continued development of the science of metallurgy. ⊖

By A. M. White
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Variations in the Quenching Power of Salt Baths

DESPITE the large and increasing use of low-temperature molten salt baths as quenching mediums there are surprisingly few data relating to the operating properties of these baths. The information that has been published includes a report by Bernard Thomas[1] that moisture in salt baths can accelerate the quenching rate to such an extent that water quenching is approached and the advantages of a salt quench might be nullified. B. F. Shepherd[2] published curves which showed greater hardness for various sizes of cylinders quenched in salt at 400° F. than when quenched in oil at the same temperature. F. R. Morral[3] has summarized the work of German investigators who measured cooling rates at the centers of round spheres during quenching in salt baths and other mediums; it was shown that there is some effect of salt bath composition, degree of agitation and moisture content of the salt on quenching power. Unfortunately, only one of the salt mixtures for which these data were obtained is commonly used in this country; furthermore, the data cannot be readily interpreted in terms of industrial quenching processes.

It has often been desirable to know the effect on quenching power of contamination of the low-temperature salt as a result of "drag-out" of austenitizing salts or from other sources, the effect of various quenching temperatures, and also to verify the reported effects of agitation and moisture content. For this preliminary investigation, one of the primary objectives was to devise a simple and easily interpreted method for comparing the quenching powers of various quenching mediums when the differences between them are small. A satisfactory method for obtaining the desired information should meet three requirements: *(a)* The method should be relatively simple, *(b)* the specimens should be of such form that they may be produced quickly, inexpensively and with good reproducibility, and *(c)* observations or measurements should be such that they can be made quickly, will require little previous preparation of the specimens, and can be evaluated easily in terms of practical information.

One commercial low-temperature salt, a ternary mixture of 53% potassium nitrate, 40% sodium nitrite and 7% sodium nitrate, was investigated. Data were obtained to show: *(a)* the effect on quenching power of the addition of 0.5% sodium chromate, *(b)* the effect of contamination by the "drag-out" from two austenitizing salt mixtures, one containing barium chloride in addition to sodium and potassium chlorides, and *(c)* a comparison of the quenching power of molten salts with that of a commercial quenching oil.

Because of the relationship of hardenability to the present problem, the possibility of adapting a hardenability testing technique was considered. None of the end-quench methods was entirely suitable because the tremendous agitation obtained during end-quenching does not adequately reproduce the conditions obtained in practice. It was also anticipated that there would be many difficulties associated with the circulation of molten salt through an end-quench apparatus. Post, Greene and Fenstermacher[4] used a cone-shaped specimen to measure the hardenability of shallow hardening steels. Such specimens were also used by Wescott and Vollmer[5] and Bastian[6] for measuring the hardening power of oils. Cone specimens would be suitable for investigation of the quenching power of molten salts except that they might

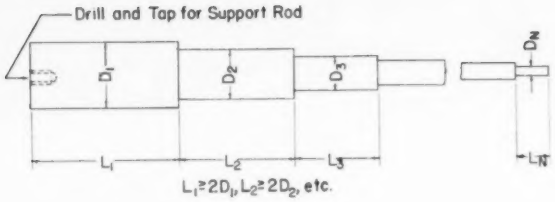


Fig. 1 — Specimen for Evaluating Quenching Power of Molten Salt

be difficult to machine under some conditions and a special fixture is required for making hardness readings along the axis of the cone.

Various methods have been used for comparisons of quenching oils. Spring, Lansdale and Alexander[7] compared commercial quenching oils and investigated the effects of several variables by means of time-temperature cooling curves for a $\frac{13}{16}$-in. diameter specimen of 18-8 stainless steel. Such data cannot be easily evaluated because comparisons of cooling curves having different shapes do not give obvious indications as to which would provide the greatest hardening. Siebert and Sandoz[8] compared quenching oils by means of an end-quench test; their conclusions differed from those of Spring, Lansdale and Alexander, probably because of the disadvantages of the end-quench test already mentioned.

In order to achieve simplicity, a method based on the mass effect seemed a logical choice. The method chosen does not require knowledge of the specific cooling conditions. When different sizes of cylinders of any one steel are quenched, the resulting center hardnesses plotted against the corresponding cylinder diameters give a smooth curve of changing slope. Similarly, the surface hardnesses plotted against diameters give a smooth curve whose changes in slope occur at larger diameters than the corresponding changes for the center hardness curves. The method of investigation is based on the comparison of the curves of hardness versus diameter of cylinder for identical specimens of the same steel for various treatments.

The specimen selected is a stepped cylinder, shown in Fig. 1. The number of steps and the dimensions depend on the hardenability of the steel that is to be tested. The principal advantage of this type of specimen lies in the fact that enough points for a complete hardness-diameter curve can be obtained from a single quench.

Procedure

A plain carbon steel containing 0.51% carbon was used because it was desired that the steel should not include significant amounts of retained austenite after heat treatment. It was predicted from the Jominy end-quench curve of this steel (Fig. 2) that the following dimensions would be suitable for the specimen shown schematically in Fig. 1: lengths of cylindrical steps — 2½, 2, 1¼, 1 and ¾ in.; diameters, respectively — 1, ¾, ½, ⅜ and ¼ in.

It may be noted that the length of each section was made to equal at least twice its diameter in order that the midlength portion would be cooled only by heat loss through the cylindrical surface and not the ends. Each specimen had an over-all length of 7½ in. and was machined from 1⅛-in. diameter bar stock. The large end was drilled and tapped to accommodate a rod for handling and agitating the specimen in the quenching medium.

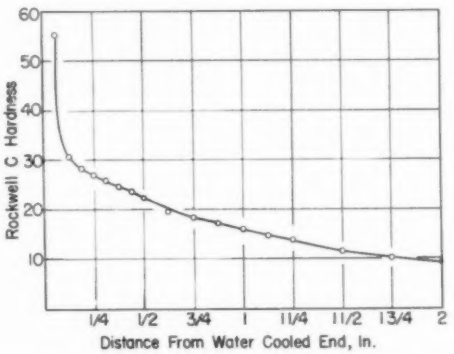


Fig. 2 — End-Quench Curve of 0.51% Carbon Steel

All specimens were austenitized in a neutral salt bath composed of barium, sodium and potassium chlorides, for 6 min. at 1550° F., and were quenched with mild agitation, according to the procedures listed in Table I. It was attempted to quench each specimen within 2 sec. of the time it was removed from the austenitizing bath. The salt used for quenching in the B treatments was taken from an 800-lb. furnace and had been mildly contaminated with "drag-out" from an austenitizing salt mixture of sodium and potassium chlorides and from three-component austenitizing baths containing barium chloride. The chloride contamination was found by chemical analysis to be equivalent to 1.1% of mixed sodium and potassium chlorides and the alkalinity, calculated to sodium carbonate, was 0.17%. The contaminated salt contained the equivalent of only 0.019% sodium chromate as a result of barium chromate

precipitation. The salts used for the A and C treatments were mixed in the laboratory specifically for this investigation and were not contaminated. The quenching oil was a commercial, modified mineral oil, which was heated as recommended by the manufacturer in order to increase its efficiency.

It may be noted in Table I that all of the A treatments were similar. For that reason they have been considered together. The same is true of the B and C treatments. (Specimens 1, 8, 9, 10, 18 and 19 were not comparable with those receiving treatments A, B and C, and are therefore not considered.)

After heat treatment, a slice ¼ to ½ in. thick was cut from the midlength of each section of each specimen by means of an abrasive wheel, which was liquid cooled to prevent burning. On each of these slices at least ten Rockwell C readings were made and the results for each section were averaged. Hardness corrections for surface curvature were made in accordance with the data of Poole and Hunt.[9] No more than four center hardness values could be obtained for averaging, but the agreement between supposedly similar readings was usually good and the accuracy of the results is believed to be adequate to support the conclusions drawn. Judging from variations of center hardness along the ⅜-in. sections, these sections were not long enough. Nevertheless, center hardnesses on each side of the midlength point were averaged and the smoothness of the curves is taken as an indication of sufficient accuracy.

Time-temperature heating and cooling curves were made for a 1-in. diameter specimen heated in the triple chloride salt at 1550° F. and quenched from the high temperature into a pot containing 800 lb. of the contaminated nitrate-nitrite salt mixture at 350° F. The specimen was 4 in. long and had a 0.15-in. diameter hole drilled to a depth of 2 in. along the axis. A ¼-in. nickel tube having a 0.15-in. inside diameter was welded to the end of the specimen as a continuation of the drilled hole. A chromel-alumel thermocouple was inserted through the nickel tubing until it was in contact with the bottom of the drilled hole. The thermocouple was connected to a potentiometer, and time-temperature curves determined on heating and cooling. Several runs were made and averaged.

Low-temperature salt baths used for quenching steel parts may become contaminated by other salts from the austenitizing bath, or by moisture. It is desirable to know whether such additions affect the usefulness of the bath. The author shows that the quenching power of a commercial nitrate-nitrite salt bath is significantly increased by contamination with 0.5% of sodium chromate, and decreased by small amounts of chloride. These results are based on a direct method of testing in which the hardness of a stepped cylindrical specimen is used to indicate effectiveness of the medium in which the specimen is quenched.

Table I — Quenching Treatments of Stepped Cylindrical Specimens

Treatment	Specimen Number	Quenching Medium	Temperature	Time	Remarks
W	3	Water	46° F.	To equilibrium	Agitated
O	2, 20, 21	Proprietary oil	130	To equilibrium	Agitated
A	4, 7, 17	Ternary salt, no contamination or additions	350	30 sec.	Agitated in 35-lb. pot and air cooled
A	11	Same as above	350	35 sec.	Same as above
A	13	Same as above	355	30 sec.	Same as above
B	5, 12	Ternary salt, contaminated	350	30 sec.	Same as above
B	6	Same as above	350	30 sec.	Agitated in 45-lb. pot and air cooled
C	14	Ternary salt containing 0.5% sodium chromate	350	30 sec.	Agitated in 35-lb. pot and air cooled
C	15	Same as above	360	30 sec.	Same as above
C	16	Same as above	355	30 sec.	Same as above

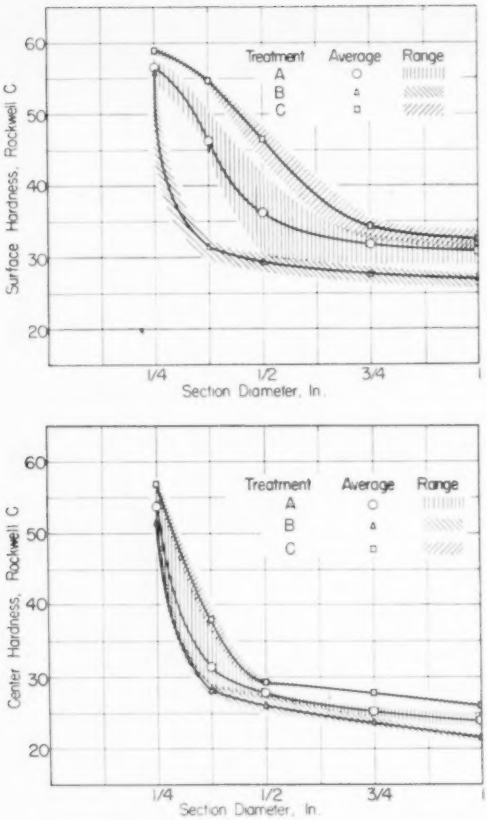


Fig. 3 — Variation in Surface Hardness (Top) and Center Hardness (Bottom) With Section Diameter of Stepped Cylindrical Specimens of 0.51% Carbon Steel. Treatment A includes five specimens and treatments B and C each include three specimens. All specimens quenched from 1550° F.

Results

Data for the various treatments in salt are presented in Fig. 3. The reproducibility of results for each treatment, represented by the cross-hatching, is reasonably good and there is little overlapping of the range for one with that of another. The comparatively wide range of results for the surface hardnesses of treatment A was caused by specimen 11 for which it was indicated by metallographic examination that there had been a delay prior to quenching which permitted transformation to pearlite at the surface without affecting transformation at the center. Despite the anomalous data for specimen 11 the average curve was not changed appreciably.

Fig. 4 shows the average curves for the salt, oil and water treatments. Only one water quenched specimen is represented but it is so different from the others that additional specimens were considered unnecessary. The curves for the oil quench treatment represent three specimens but the spread of the values which were averaged is large. More data for oil quenched specimens might change the curves somewhat, probably in the direction of higher hardness.

It was realized that equalization at 350° F. was probably not obtained in 30 sec. for some parts of the specimen. Direct evidence of this is obtained from the average time-temperature cool-

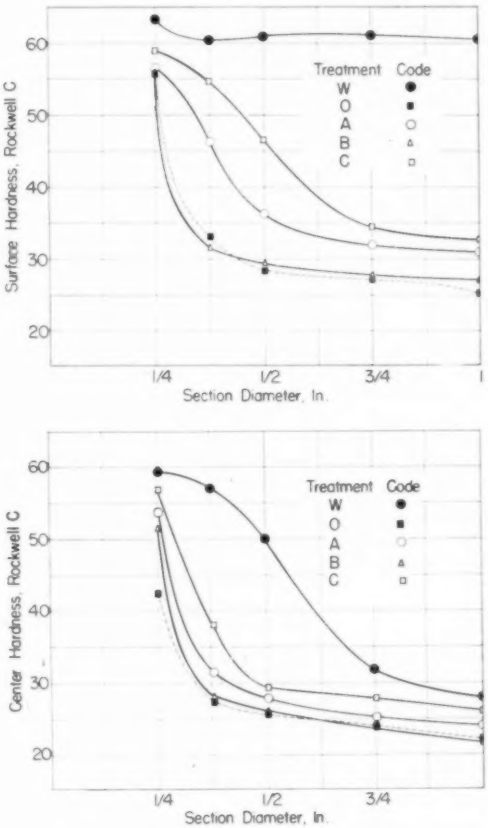


Fig. 4 — Variation in Average Surface Hardness (Top) and Average Center Hardness (Bottom) With Section Diameter of Stepped Cylindrical Specimens of 0.51% Carbon Steel. Treatment W includes one specimen and treatment O includes three specimens. Curves for treatments A, B and C are from Fig. 3

ing curve of Fig. 5, which was determined for a 1-in. diameter specimen in the contaminated salt. It may be noted that the center of a 1-in. diameter cylinder reaches about 780° F. in 30 sec. but requires about 2 min. to reach the bath temperature of 350° F. This is considerably more rapid cooling than was reported by Shepherd,[2] who showed that a 1-in. diameter cylinder required 5 min. to come to equilibrium in a salt at 400° F. when quenched from 1550° F. The heating curve of Fig. 5 shows that it requires nearly 5 min. to heat a 1-in. round to the salt temperature. Thus, it was established that the austenitizing time of 6 min. was adequate but that the quenching time of 30 sec. was inadequate for attaining equilibrium in the 1-in. diameter section.

The results show that the fresh salt mixture containing sodium chromate had the greatest quenching power and the contaminated salt had the poorest quenching power. The intermediate position of the fresh salt which did not contain sodium chromate is evidence that the inferior properties of the contaminated salt were not caused solely by the precipitation of chromate and suggests that contamination from a sodium chloride – potassium chloride salt mixture, which would not cause chromate precipitation, would also be detrimental. Despite the greater scatter it is apparent that differences can be detected more readily by surface hardness measurements than by center hardnesses.

From Fig. 4 it is seen that the hardnesses obtained by the oil quench treatment compare favorably with the least efficient of the salt quench treatments. Even though the data for the oil quenched specimens are few, it is unlikely that more data would change the trend enough so that the oil quench would show superiority over the quench in uncontaminated salt without sodium chromate.

It is apparent that the dimensions chosen for the specimen might have been improved for the 0.51% carbon steel; there are too few points in the range where the hardness change is greatest. More sections of smaller diameter or a steel of slightly higher hardenability would have permitted better curves to be drawn.

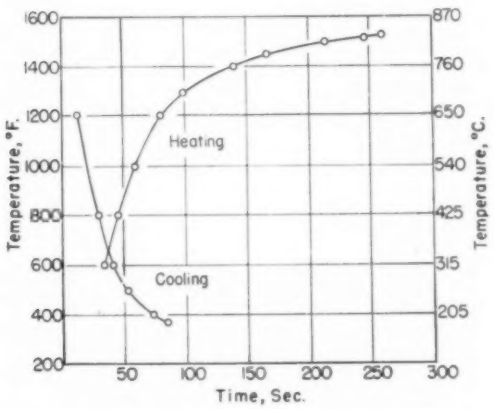
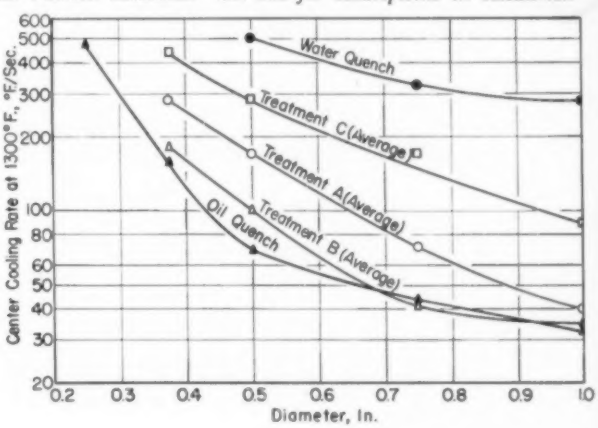


Fig. 5 — Time – Temperature Heating and Cooling Curves for 1-In. Diameter Carbon Steel Specimen in Contaminated Nitrate – Nitrite Salt Bath. Specimen was heated from room temperature in chloride mixture at 1550° F. and then quenched into low-temperature bath at 350° F.

Calculation of Approximate Cooling Rates

From the data obtained, cooling rates for various sizes of rounds in the quenching mediums tested can be determined by an indirect method. For such a determination it is necessary to assume, despite evidence to the contrary by Manning,[10] that the cooling rate at the center of any section is the same as the cooling rate at that location in the end-quench specimen for which the hardness is the same. By further assuming that the cooling rate at 1300° F. is the criterion for hardening, and using the data of Boegehold and Weinman[11] for cooling rates in an end-quenched specimen, the cooling rate curves of Fig. 6 were obtained. Because of the steep slope of the end-quench curve near the quenched end and of the hardness-diameter curves at small diameters, points for the smaller diameters were omitted.

Fig. 6 — Approximate Cooling Rates for the Centers of Round Bars in Various Mediums. See text for assumptions in calculation



Summary

It has been shown that the quenching power of a low-temperature salt bath whose base composition consists of 53% potassium nitrate, 40% sodium nitrite, and 7% sodium nitrate undergoes significant change as a result of small amounts of impurities. The addition of 0.5% sodium chromate considerably increased the hardness obtained on 0.51% carbon steel specimens of various diameters hot quenched in this salt mixture for 30 sec. at 350° F. and then air cooled. Contamination by chlorides of alkali metals and alkaline earth metals carried over from austenitizing salt baths caused a decrease in the quenching power. Some of the harmful effect was the result of precipitation of chromate by the barium chloride of the austenitizing salt but the hardnesses were even lower than were obtained with an uncontaminated salt not containing sodium chromate. The mechanism by which the quenching power is altered has not been investigated.

The quenching oil which was used gave results similar to those obtained with the contaminated salt. However, the temperature of the oil was considerably lower than that of the salt and, as shown by comparison with the data of Shepherd,[2] was more efficient than if it had been at the same temperature as the salt. Actual cooling curves for a 1-in. diameter cylinder held in the poorest salt at 350° F. showed that it reached the bath temperature more rapidly than Shepherd's similar specimen quenched into a salt at 400° F. This suggests the possibility that the salt used by Shepherd was contaminated to a greater extent than the impure salt used in this investigation and, thus, had a lower quenching efficiency.

The method by which the quenching phenomenon was investigated was based on the mass effect and proved to be satisfactory despite variations from specimen to specimen for similar treatments. The differences between salts and the variations between specimens treated in any one salt were greatest for the surface hardnesses and comparatively slight for center hardnesses. It is therefore suggested that the scatter for any one treatment might be due to the speed of transfer of the individual specimens into the quenching bath and that the differences between treatments might be an indication that it is the early stages of cooling that are most affected by slight changes in the salt composition.

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Pretreatment of Aluminum Sheet for Painting

MANUFACTURERS frequently wish to paint products fabricated from aluminum sheet. Toys, for example, are given added sales appeal by brightly colored finishes, and clothes hampers are painted to match interior decorative schemes. Production of a high-quality painted finish on aluminum sheet involves only one problem — getting good adherence.

The newly developed phosphate coatings for aluminum and its alloys have been found to provide a highly satisfactory paint base. These coatings are thin, hard, tight, and contiguous with the base metal because they *replace* the natural oxide coating present on all aluminum. The adherent coating supplied by Reynolds Metals on its "Alumi-Grip" sheet and plate is from 15 to 50 micro-in. thick, appreciably thicker than the normal oxide coating of about ½ micro-in. In processing this sheet, an extremely thin layer of the base metal is dissolved to form the aluminum phosphates and other compounds that make up the coating.* The result is virtually no over-all increase in thickness of the sheet, even though the coating produced may be many times thicker than the oxide coating it replaces.

The reason this coating provides such an excellent paint base is twofold: *(a)* The coating itself is integral with the aluminum base metal and can be removed only by chemical methods or by systematic abrasion, and *(b)* the surface of the coating is full of minute cracks or pores which provide "teeth" to key or interlock paint to the coating. The net result is that any kind of paint, lacquer, or enamel can anchor itself firmly to the metal surface — so firmly in fact that chipping or cracking of paint coats is almost completely eliminated. Even the expensive anodizing treatment offers no better anchor action than the phosphate coating.

This coating is also lightfast, inorganic, harder than the aluminum under it, corrosion resistant (meets Air Force-Navy Aeronautical Specification AN-C-170), and stable at temperatures up to 1200° F. The sheet can be formed or given light draws without breaking the coating.

Mill Processing — Because of the many demands for sheet aluminum with a good paint base applied at the mill, Reynolds Metals recently installed large facilities for producing this coating on both flat and coiled aluminum sheet. The first installation was made at Louisville Plant 12 where flat sheets are hung edgewise and carried through the treating chambers on an overhead chain conveyer. The second installation was made at Reynolds' McCook (Ill.) plant where a continuous coil handling setup stitches the tail end of one coil onto the leading end of the next coil. Except for the mechanical handling facilities, the two installations are quite similar; the treating equipment is zoned in sections to apply first a cleaning solution, then a cold water rinse, an Alodine† solution, another cold water rinse, followed by an acidulated rinse. The rest of this article describes the Louisville installation.

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*According to F. P. Spruance, Jr., American Chemical Paint Co., inventor of the coating process, a typical coating composition is as follows: 53.5% $CrPO_4$, 21.7% $AlPO_4$, 1.2% $CaHPO_4$, 0.4% $AlPO_3$ and 23.2% water. Most of the water is driven off in the drying oven during the last step of the process. Spectrographic data yielded the following analyses (expressed in milligrams per square foot of surface area): 3.85 mg. calcium, 102.2 mg. chromium, 2.16 mg. fluorine, and 128.2 mg. phosphorus.

†A product of American Chemical Paint Co.

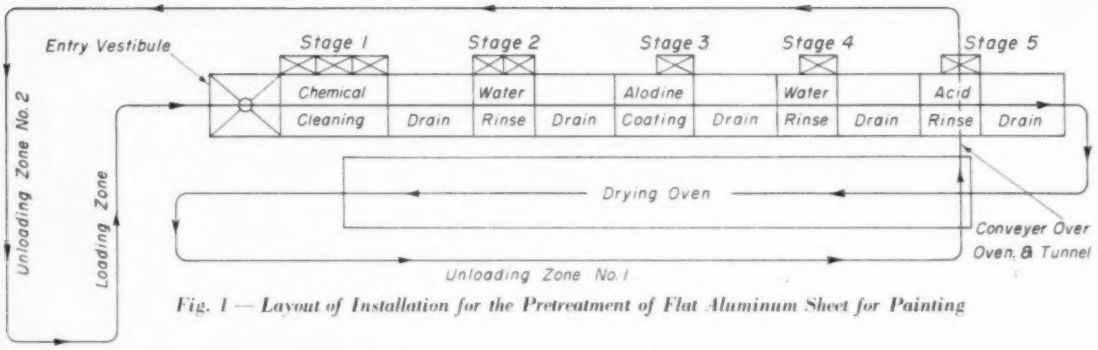


Fig. 1 — Layout of Installation for the Pretreatment of Flat Aluminum Sheet for Painting

Louisville Installation

The conveying equipment is designed to handle any size of flat sheet up to a maximum of 48 x 144 in. Referring to Fig. 1, the loading and unloading sections of the conveyer are 7½ ft. from floor to bottom of the conveyer rail. This allows 3½ ft. for floor clearance and for the pantograph clamps that are used to attach sheets to the conveyer.

Although the conveyer chain is equipped with hooks at 2-ft. intervals, sheet clamps are spaced on the hooks according to the length of sheet being processed. The weight of the sheet itself provides the clamping action through the pantograph leverage system shown in Fig. 2, p. 828. The pantograph clamp automatically adjusts clamping force to weight of sheet and so prevents damaging or marking the sheet. This type of clamp is easy to load and unload and has no springs or threads to cause trouble from buildup of the coating.

In order to prevent bending of the long sheet when it moves around sharp corners in the conveyer, the trailing clamp on each sheet rides on a rod, in turn supported at two places on the chain. This system allows the pantograph clip holding the sheet to slide back and forth on the rod, thus automatically compensating for difference between chain length and sheet length when turning corners.

From the 35-ft. loading zone, the conveyer rises until the bottom of the rail is 11½ ft. from the floor. Work enters processing chambers at this height. The additional 4 ft. of height is sufficient to raise the drainage levels above the tanks and yet allow the solution tanks to rest on the floor. This avoids the difficulties encountered when tanks must be set below floor level and permits all piping, pumps and drains to be serviced readily. The main conveyer tunnel through which the work passes is 7 ft. wide, approximately 7½ ft. high, and 96 ft. long, containing in a straight line the following processing chambers:

Entry vestibule, 8 ft. long, has floor sloping back to washing chamber, contains a vent with a ½-h.p. fan discharging to a 24-in. diameter stack, top of which is 32 ft. above the floor.

First stage is for chemically cleaning the work. This chamber is 12 ft. long, with 221 spray nozzles operating at 20 psi.; most of these spray the work horizontally, except 26 which spray down and 26 which spray up. This arrangement will handle a wide variety of formed parts in addition to flat sheet. Nozzles are V-jet type mounted on 26 2-in. diameter risers, fed at the top by 3-in. headers and in turn served by a 5-in. diameter main from a 750-g.p.m. (65-ft. head) centrifugal pump. After striking the work, the solution falls into the 2400-gal. tank immediately below and is recirculated through the spray heads.

The next 10 ft. down the tunnel forms a drain section. In the first 8 ft., the floor slopes back toward the first stage to return any solution which drains off in this area. The last 2 ft. slopes toward the next spray stage to return any overspray to that tank.

Second stage is a cold water rinse. Here 119 V-jet sprays operating under 20 psi. are mounted on 14 2-in. risers fed by a 450-g.p.m. (60-ft. head) centrifugal pump through a 5-in. main and 3-in. headers. This section of the tunnel is 6 ft. long. As in the first stage, the rinse water falls from the work into a 1200-gal. tank directly below. The last pair of risers in this second stage is connected directly to the fresh water main to provide effective rinsing and a continual supply of fresh water to prevent buildup of cleaner in the rinse.

Third stage, where the phosphate coating is produced on the sheet by a solution of Alodine (or similar material), follows a 9-ft. drain section. The solution is sprayed on the work through 153 stainless steel full-jet-type nozzles operating at

10 psi. distributed on 18 1½-in. diameter stainless steel risers extending down both sides of this 9-ft. section of the tunnel. All portions of this tunnel section are constructed from stainless steel. Risers are connected to a 2-in. stainless steel header pipe from a 3-in. main fed by a 150-g.p.m. (40-ft. head) stainless steel centrifugal pump. After striking the work, the solution falls into an 810-gal. stainless steel tank immediately below for recirculation through sprays. The conveyer then carries work through a 9-ft. drain section provided with a ½-h.p. exhaust fan connected to a 24-in. stack extending 32 ft. above floor level.

Fourth stage is a cold water rinse with 119 full-jet-type nozzles operating at 12 psi. and mounted on 14 1½-in. risers distributed along both sides of a 7-ft. long section of the tunnel. A 150-g.p.m. (40-ft. head) centrifugal pump feeds the spray nozzles through a 3-in. main and 2-in. headers. Water drains back into an 800-gal. tank immediately below the sprays, for recirculation.

Fifth stage applies an acidulated rinse such as Deoxylyte, using 119 full-jet-type nozzles working at 15 psi., mounted like those in the fourth stage and using the same piping and pumping arrangement. Two steam jets strike the work to rock it and help knock off any remaining water. This is especially important when treating fabricated items such as vegetable trays for refrigerators, which may need to be rocked to prevent trapping solution. This section is 7 ft. long.

Drying Oven — After coming out of the processing tunnel, the conveyer makes a turn and drops down to the lower level where it carries work on through a drying oven which is located alongside the tunnel as shown in Fig. 1. The oven operates at 350 to 400° F., depending on the aluminum alloy being treated and the speed at which the conveyer is running. Drying is essential to allow immediate painting or packing.

The oven is 70 ft. long, 8 ft. wide, 8 ft. high. Besides the main housing, a 4-ft. square canopy extends over both entrance and exit ends. A heat seal system provided at both entrance and exit silhouettes employs a blast of hot air blown upward from slots that extend across the oven at floor level. Hot air is supplied the oven by electric heating equipment providing 1,200,000 B.t.u. per hr. Heating equipment, fans, and controls are located on top of the oven.

Silhouettes — At entrance and exit of the processing tunnel and immediately before and after each spray section are baffle plates across the tunnel with an opening cut out to allow the conveyer and work to pass. These baffles cut down overspray into adjoining drain sections and help keep the solutions separated.

Process Solutions

Cleaning Solution — Stage 1 contains the alkaline cleaner made up by adding Ridoline (American Chemical Paint Co.) or similar material to the 2400-gal. tank of water, employing compressed air to agitate the solution while the cleaner is being added in powder form. Every two weeks (one-shift operation) the tank is drained to remove sludge, and a new solution is mixed.

The cleaning solution is maintained at correct strength automatically by use of a newly developed device called the "Ridotrol", also made by American Chemical Paint Co. Its operation is based on the decrease in electrical conductivity of the solution during use. The conductivity is measured continuously by means of two copper wire electrodes immersed in the tank. The electrodes are connected to a circuit and sensitive relays are calibrated to actuate a small electrically driven pump as soon as the concentration falls to 1¾ oz. per gal. This pump meters into the bath a concentrated cleaning solution (2 lb. per gallon) at the rate of 20 g.p.m. from a separate 200-gal. tank. As soon as the concentration of the bath has been raised to 2 oz. per gal., the control circuit cuts off the pump.

First Rinse — Stage 2 is a plain water rinse. It is maintained at desired purity by the sprays on the last two vertical risers, which are connected directly to the fresh water main. Overflow here, as in all tanks, is through a 2-in. line connecting top of tank to sewer. The tank is drained completely every week to remove any sludge.

Coating Solution — Stage 3 contains the phosphate coating solution, which is made up by adding 65 gal. Alodine liquid No. 100 and 145 pounds of Alodine makeup powder No. 1 to enough water to fill the 810-gal. tank. The desired strength is maintained by a proportionating pump which runs continuously to add 1.5 gal. per hr. of a concentrated solution made by mixing 16 gal. of Alodine liquid No. 100 and 100 lb. of Alodine replenishing powder No. 10 to 67 gal. of water.

The bath is checked every 4 hr. of operation by titrating a 5 c.c. sample with 1.0 normal sodium hydroxide solution. If the concentration checks out on the low side, the speed of the proportionating pump is increased; if concentration is on the high side, rate of pumping is decreased. Two tanks are used for the concentrated replenishing solution. When one becomes empty, the proportionating pump is changed over to work out of the other tank while a new batch of solution is mixed in the first tank. Every two weeks (one-shift operation) the entire Alodine bath is pumped over into an adjoining tank while sludge is cleaned from the bottom of the tank; then the solution is

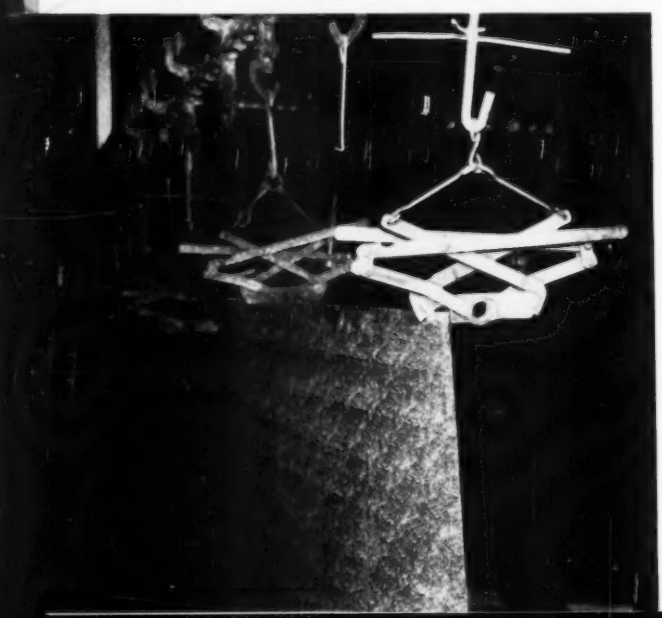
returned. This makes it unnecessary ever to discard the coating bath.

Second Rinse — Stage 4, a plain water rinse, is maintained at desired purity like Stage 2 by the sprays on the last two vertical risers which are connected directly to the fresh water main. The tank is drained weekly and any sludge removed.

Acidulated Rinse — Stage 5 contains the acidulated rinse which produces the desired "tooth" in the phosphate coating and renders harmless the alkaline-reacting salts that are present in ordinary water. To make up this solution, 20 oz. of Deoxylyte No. 9 and 20 oz. of Deoxylyte No. 10 (or similar materials) are added to 800 gal. of water in the tank for this stage and adjusted (if necessary) to produce a pH value of 4 to 5. This bath is maintained at the correct strength by a proportionating pump which runs continuously to add to the bath 2 gal. per hr. of concentrated replenishing solution. Fresh water is also added continuously at the rate of 15 g.p.m. Replenisher is made up by mixing ½ gal. of Deoxylyte No. 10 and ¼ gal. Deoxylyte No. 9 with 45 gal. of water in a 75-gal. tank.

Strength of this bath is checked every 4 hr. of operation by titrating a 100-c.c. sample against a 1.0 normal sodium hydroxide solution. If acidity checks out high, the flow of fresh water is increased above the normal 15 g.p.m.; if the acidity is low, the variable speed drive on the proportionating pump is adjusted to increase the rate of addition of replenisher. In addition, the 100-c.c. sample is checked for maximum limits on total acid and on free acid content.

Fig. 2 — Pantograph Type of Clamp Employing No Springs. Clamping force is adjusted automatically to weight of sheet; this prevents marking of the sheet. Embossed sheet shown



Control

Automatic Temperature Controls — Tanks for Stages 2 and 4 are not heated. Tanks for Stages 1, 3, and 5 are heated by steam coils. Each tank is controlled individually. Thermocouples in the bath are connected to indicating and recording controllers which in turn operate motorized valves adjusting heat input by changing the rate of steam flow. Each of the three heated tanks has its own individual temperature controlling and recording system. When the system was first set up, temperatures were adjusted to find the optimum working point. Now, however, they are not changed at any time. Bath temperatures are held within ±2° F. of the following values: Stage 1, 160° F.; Stage 3, 110° F.; Stage 5, 150° F.

System Control — The system is adjusted according to the size of sheet being processed because this determines the speed at which the two operators can load the conveyer. (Two other workers unload the conveyer.) For average work, the conveyer is operated at 24 f.p.m. At this speed, the work is in Stage 1 for 30 sec.; Stage 2, 15 sec.; Stage 3, 20 sec.; Stage 4, 15 sec.; Stage 5, 15 sec.; drying oven, 2½ min. However, for small embossed sheet which takes longer to load and requires more time for proper drainage, the conveyer may be slowed down to 18 f.p.m. On the other hand, large flat sheet can be loaded and unloaded faster so the conveyer may be speeded up to 32 f.p.m. or more. The over-all range of speeds is from 12 to 40 f.p.m.

As the conveyer speed is increased or decreased, the processing time in each stage likewise decreases or increases. This variation is well within operating limits except for Stage 3, the Alodine stage. Here two adjustments are made as required: The first involves varying the concentration of the Alodine bath, by slowing down or increasing the speed of the replenishing pump. The second is by varying the pressure at the spray nozzles, through throttling the main line from the centrifugal pump. Lower spray pressures result in a lighter coating, thus compensating for longer spray periods at the lower conveyer speeds.

Quality Control — The phosphate coating produced is normally a light green in color. (Alloy composition affects the color somewhat.) This makes it possible to check quality quickly and easily by comparing the work against standard panels. This visual inspection includes color, iridescence, powdering, and general appearance. In addition, a paint adherence test is run at regular intervals, using high humidity and salt spray under controlled conditions. This provides an actual check of the coating as a paint base.

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Naval Engineering Duty in Peacetime

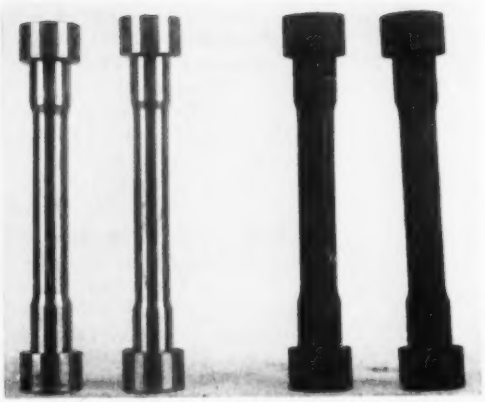
THREE years ago *Metal Progress* published the account of my experiences as a naval engineer during the wartime years ("Naval Engineering Duty in Wartime", September 1946). Then I commented that the greatest part of the engineer's duty was in standing by, making preparations for combat, while the actual shooting time was far less. I described the duty as prosaic, unglamorous, routine and absolutely necessary. It appears to be pretty much the same in peacetime, especially in the so-called "mothball fleets", the Atlantic and Pacific Reserve Fleets, the reserve sea power held in readiness to augment the active fleets.

In September of last year when the Navy requested volunteers for recall to active duty for a year's cruise, my immediate assignment was to the Norfolk Group, Atlantic Reserve Fleet, as assistant material officer for engineering (machinery), electrical and dehumidification problems. I was not at first impressed with what appeared to be an unimaginative job. After nine months, however, even in a duty that is dull as compared with the operations and movements of the active fleet, it is evident that there are many opportunities for ingenuity and engineering imagination. And the monotonous duties of chipping paint, removing rust and applying preservatives have as important a part in the national defense as those of conducting gunnery exercises and war games.

I may well begin with the usual statement that the remarks, comments and opinions hereinafter expressed are those of the writer and do not in any respect reflect nor represent those of the Navy Department; they are neither approved nor disapproved by the Department or the Atlantic Reserve Fleet; and they have no official significance. They are, in short, the observations of a civilian in uniform.

Corrosion — The enemy of a reserve naval force is as serious as the depredations of a fighting naval opponent. The major enemy of the reserve fleets is corrosion, in one form or another; deterioration of nonmetallics may not, strictly speaking, be corrosion but the source is the same — moisture, or its absence. Metals, clothing, leather and electrical equipment suffer from exposure to an excess of moisture; wood, cordage, paint, gaskets and the like, suffer from its absence; and to make the picture more confusing, some things like electrical insulation may deteriorate from too little *or* too much moisture. As the effects of dehydration are less serious, our maintenance problems in this respect are not disproportionate.

Early in the 1920's, the Navy Department began studies with the assistance and cooperation of industry to determine the best preservative methods and the most suitable materials. Although many improvements were made in preservative coatings, it became increasingly obvious that the attacks of corrosion were best and most economically defended by eliminating the active corrosive agents. Preservative coatings, however, were conceded to be the sole means of protection for exposed surfaces such as the outer skin of a ship, portions of which may be under water while the rest is at the mercy of wind, rain, sun, spray, snow or moisture vapor. These tests culminated in certain conclusions, mainly that at 30% relative humidity, active corrosion will stop and mildew, rot and mold will be so retarded that they are practically ended.



30% Relative Humidity 90% Relative Humidity

Fig. 1 — Mild Steel Specimens After Three Years of Exposure to Different Humidities

Dehumidification

Elimination of the major enemy within the hull — moisture vapor in the air, expressed as humidity — is best accomplished by circulating dry air within the hull. Solid desiccants such as silica gel, activated alumina or bauxite are the drying agents; electrical energy in the form of heat reactivates these drying agents when they become saturated; and electrically powered fans circulate the dehumidified air throughout the ship. Automatic equipment regularly samples the air, records temperature and humidity and energizes or secures the dehumidifiers. Desiccants which are physical, rather than chemical, in their water adsorption characteristics are preferred because they may be reactivated by heat, giving up their water vapor to air which is discharged from the hull. Chemical desiccants like calcium chloride form a liquid salt solution which would not be so easily removed and would not be reactivated simply, thus requiring constant replacement.

There are several ways in which moisture can reach the interior of a ship to cause deterioration: by leaks in the hull structure for presence of moisture in the natural state; by entrance of humid air through cracks and crevices too small to be detected easily; and by entrance of moist air when doors and hatches are opened for the necessary daily security inspections and maintenance work. Entrance of water through hull openings below the water line is probably the least important of these possibilities; one of the primary duties of the security patrol is to search for this rare condition. Rain or snow or spray may leak in through corroded topside drains or fittings and vent trunks or around doors and hatches where gasket materials have deteriorated, or through the small openings at expansion joints and cableways which appear to be sealed but are not. Every possible effort is made to locate and seal these leaks but some escape detection.

Naturally, if the hull structure could be hermetically sealed, humid air would soon be of slight concern. Unfortunately, most ships, particularly in the superstructure areas, are not easily pressure tested; moreover, some areas are of light sheet-metal construction with metal joiner doors rather than pressure-tight closures. If the pressure of the dehumidified air inside the hull could be maintained always above atmospheric, preservation problems would be greatly lessened; air compressor requirements make this idea difficult of accomplishment. Actually it would be entirely satisfactory if we could run our ships under sheds high in the Arizona desert but if I may be permitted a slight understatement, that does not appear to be entirely practicable.

Fig. 2 — Test Cabinet After Three Years of Exposure to Atmosphere of 90% Relative Humidity

The effectiveness of the dynamic method of dehumidification is readily illustrated in Fig. 1, 2 and 3, which are reproduced from the *Journal* of the American Society of Naval Engineers, Vol. 60,

No. 2, "The Importance of Controlled Humidity in Longtime Preservation", by Commander George C. Wells, U. S. Navy. Better than those photographs are the actual conditions encountered when ships which have been under dehumidification have been reactivated, either for test purposes or because they have been ordered back to the active fleets to meet the changing needs of the service. They go back to duty, within the estimated or planned time periods, ready for action, in as good condition as when they went out of commission. And that's what counts!

Long dependent on imports of ores or refined forms of manganese, chromium, cobalt, tungsten and tin, American industry has a direct interest in the efficiency and reliability of transportation by sea. In peacetime, control of the sea lanes is maintained by the merchant marine, with the U.S. Navy standing by. Thus, many of the Navy ships that were so recently the nation's first line of defense are now decommisioned. But even inactive ships require engineering services. In this article, Mr. Doughton describes some technical problems of the reserve fleets.

Routine of Decommissioning

Possibly the method of preserving a ship will help to reveal her status for the future, her potential readiness for sea. The Chief of Naval Operations, for example, orders her to report to the Commander, Atlantic Reserve Fleet, for inactivation and decommissioning; he, in turn, assigns her to a Group Commander who will supervise the actual details of the procedure and provide permanent berthing. As funds permit, she is given a complete overhaul unless her material condition permits the equivalent of voyage repairs only. Her bottom is scraped, sandblasted and coated with anti-fouling anti-corrosive compounds; propellers are inspected, straightened and balanced if needed; strut and stern-tube bearings are specially treated. The hull is given a new paint job. Boilers are cleaned on fire sides and water sides; main propulsion units, auxiliary machinery and pumps are preserved with applications of thin-film rust preventive compound, a Navy development. Steam, condensate, fresh and salt water piping is drained and "fogged" with the compound. Electrical circuits and equipment are ground-tested and insulation readings recorded. Finally, all corrodible metal surfaces are protected by spraying or brushing with the thin-film rust preventive. Oil systems are usually well protected by their own oil coating and require no additional preservative methods.

Fig. 3 — Test Cabinet After Three Years of Exposure to Atmosphere of 30% Relative Humidity

Dehumidifiers are installed at the locations considered most advantageous for inspection accessibility and for balanced air flow throughout the ship. In order to circulate the dehumidified air to all compartments of the ship, zones are established within the water-removal and air-flow capacity of the dehumidifiers. To route air from the dehumidification machines for optimum flow, certain designated hatches and doors are closed and sealed while others are ordered left open. In some areas, where flow of the dry air would be restricted because no natural ventilation openings exist, holes may be cut in the bulkhead or deck if they will not violate water-tightness. In

many compartments flow of the dehumidified air is routed through fabricated sheet-metal piping or flexible canvas hose; frequently the fire-main is used for this purpose below decks.

Not all of the ship's internal areas are preserved by dynamic dehumidification methods. Compartments such as peak tanks, ballast tanks, chain lockers, voids, cofferdams and many storerooms may be located so that there is no normal connection to the more accessible spaces of the ship. In these instances, it would be difficult if not virtually impossible to provide means for the circulation of dry air without violating watertightness, which would potentially permit successive flooding of adjacent compartments in the event of hull rupture as from collision or sabotage. All these spaces are subjected to a static form of dehumidification; that is, by installing bags of solid desiccant and closing the compartment.

Thin-Film Rust Preventive

Topside machinery and equipment such as cargo and boat winches, searchlights, permanently mounted navigational aids and guns are usually preserved with thin-film rust preventive compound and enclosed in metal "huts" which are sealed against the atmosphere and either connected with a dehumidified zone of the ship or dehumidified by small "package machines" serving several such units. Exposed electrical gear and other equipment not easily removable are covered with plastic sealing compounds and tape.

Perhaps you will ask why the thin-film rust preventive compound is used if dehumidification measures are sufficient alone. Partly for reasons of insurance in the event of derangement of dehumidification machinery, for additional protection in those areas not under dynamic dehumidification and because of the possible necessity for speed in a future reactivation period. Machinery with inspection plates, housings or casings removed to permit circulation of dehumidified air through the system would have to be closed at the time of reactivation, thus consuming valuable time which might be of grave importance.

Inactivation Records

While this mechanical work is being accomplished, all departments of the ship (operations, gunnery, engineering, supply, medical) are inventorying their supplies and equipage, and preparing requisitions for any shortages. Naturally, those items which will not deteriorate will be stowed on board in their normal stowage locations; those which will suffer from aging are transferred to a supply activity ashore for re-issue to active ships. Each department is completing its machinery history, preparing all records and logs to report the exact status of all items of operation and maintenance up to the date of decommissioning. Incidentally, all changes or alterations and repairs made while the ship is out of commission will be recorded in these same logs by the Reserve Fleet Group in which she is berthed. These records will remain on board ready for the time when a new ship's company may report to prepare her for active duty. Each detail of the inactivation process is specifically described; any conditions of machinery or equipment and supplies which have been changed from the normal status or location because of the inactivation or preservation measures, are reported and special reactivation steps are listed for each unit of each department, for each compartment or space in the ship.

At the end of the inactivation period, the ship is decommissioned and officially joins the reserve fleet. Her active days are over, for the present. The decks which felt the pounding of hurrying feet racing to answer the strident clamor of the general alarm now will know only the deliberate tread of the security roving patrol; engines which but a few weeks ago turned over steadily, driving her from operation to operation, rest quietly on their bed-plates; the guns which once spat death and destruction at enemy shores, ships and planes, do not even heed the daily target practice of intrepid sea gulls. In the Register she is now OCIR — Out of Commission In Reserve.

Periodically men of the Reserve Fleet Group will chip and paint the decks and hull exposed to the relentless attacks of sun, wind, rain and snow. Less frequently, but at stated intervals, she will be towed to a naval shipyard and be drydocked so that the effects of underwater attack on hull, struts, outboard shafting and propellers can be ascertained and corrected if required. The dehumidification maintenance men will inspect her dehumidification machinery frequently, recording the temperatures and humidity readings for each zone of the ship, searching for air leaks in any zone higher in humidity than the desired 30% maximum. Alterations and modernization improvements will constantly be planned to make her ready for the ever-changing needs of modern naval and air warfare.

When I return to civilian life, it will be with the confident assurance that if it is ever necessary to train out the guns again, there's a lot of reserve naval power that can be taken out of mothballs quickly to clear the sea lanes just as effectively as was done a very few years ago.

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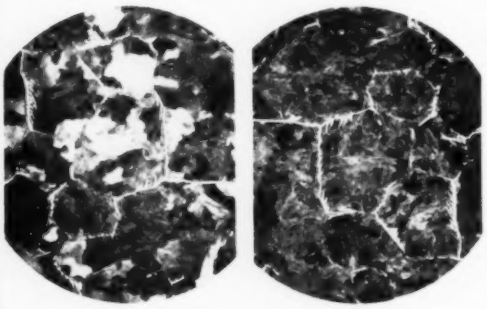
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Metallographic Technique for Steel

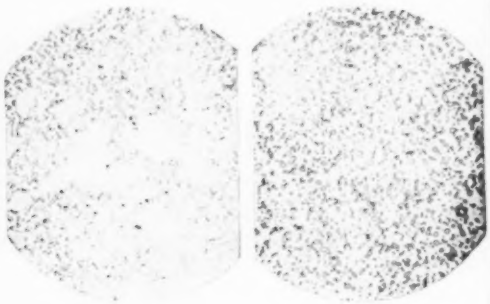
Etching Action of Nital and Picral

Sheet V of Six Prepared by Research Laboratory, U. S. Steel Corp.



1% Nital 4% Picral

Pearlite, 500×*



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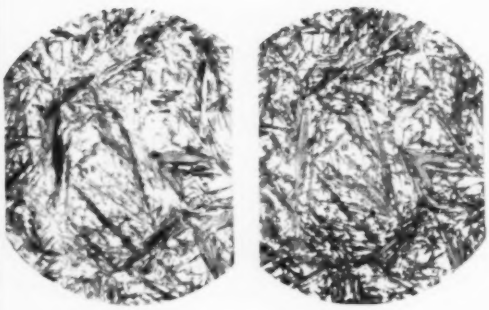
Spheroidite, 1000×*



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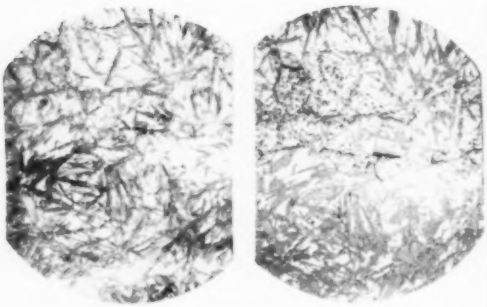
Martensite, 1000×*

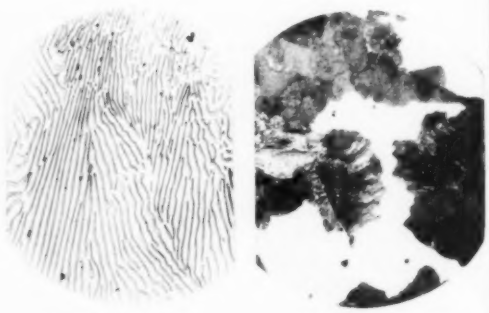


1% Nital 4% Picral

Undissolved Carbides, 1000×*

925° F. Bainite 550° F. Bainite

Etchant: 4% Picral; 2500×*



1325° F. Pearlite 1150° F. Pearlite

Etchant: 4% Picral; 2500×*

*Reproductions herein have been reduced to about one third the original magnifications noted

See also "Metallographic Technique for Steel", by J. R. Vilella, published by The American Society for Metals

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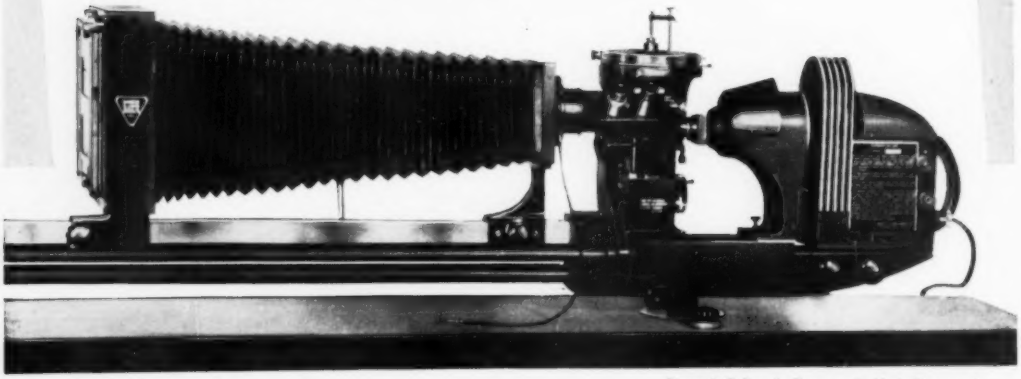
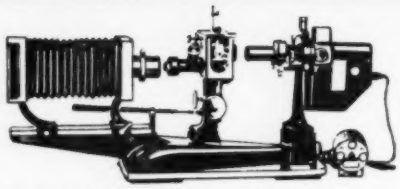


Bausch & Lomb Research Metallograph



Bausch & Lomb MILS Metallograph
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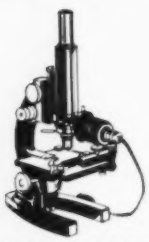

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By George H. Found
Manager, Technical Service and Development Dept.
Magnesium Division
Dow Chemical Co., Midland, Mich.

Efficient Magnesium Castings—Their Design & Production

DESIGNERS and fabricators are facing today the old, old demand for improving service performance of metallic components, at lower cost and lower weight. This is responsible for the large current interest in light metals, particularly magnesium. One rather serious complication arises from the fact that dynamic loading is dominant in determining the adequacy of the designs and alloys adopted. It is amply proven that a mere substitution of one metal for another, without obtaining its full structural efficiency, frequently results in lower performance for a given weight, and even malfunctioning of the part.

To avoid such disappointments, the designer and fabricator (as well as the intelligent buyer) must have reliable data on the physical properties of the materials to be considered. This paper will attempt to present such data for magnesium castings. Special effort will be made to show how laboratory tests correlate with service experience on parts very carefully designed with the aid of experimental stress analysis. The available data will be interpreted in terms of the influence of variables arising from fabrication processes including grain size, porosity, stress concentration, surface finish, and residual stress. These data should assist in problems of *substituting* magnesium in designs proven in other materials. They also should complement stress analysis so that *original* designs can be evolved with less time and effort than by using less direct methods.

Fatigue Properties—There is only a vague correlation between static and fatigue strengths of metals. Structural failures from statically applied loads rarely correlate with fatigue failures; the latter always occur at points of highest stress concentration despite the thickness of adjacent wall sections and despite certain other variables such as metallurgical quality important to the static properties of the structure.

It is important to consider the type of fatigue data that would be useful for design purposes.

Bending is the principal mode of stressing of some structural components. Others involve axial loading. Because the fatigue properties of magnesium differ for each of these modes, data for each are presented in Fig. 1 and 2, p. 834. These include an additional consideration, namely that alternating loads in service are nearly always superimposed upon a steady load, and this circumstance must be taken into account.

Compositions and static tensile properties of the alloys tested appear in the table below.

Table I—Cast Alloys Tested for Endurance

Designation		Condition*	Typical Tensile Properties		
Dow	A.S.T.M.		Ultimate Strength	Yield Strength	Elong. in 2 In.
H†	AZ63	AC	29,000	14,006	6%
		HT	40,000	14,000	12
		HTA	40,000	19,000	5
		HTS	40,000	17,000	7
C‡	AZ92	AC	24,000	14,000	2
		HT	40,000	16,000	10
		HTA	40,000	23,000	2
		HTS	40,000	20,000	3

*Symbols: AC—As cast; HT—Solution heat treated; HTA—Solution heat treated and aged; HTS—solution heat treated and stabilized.

†Nominal composition: 6% Al, 3% Zn, 0.2% Mn, remainder Mg.

‡Nominal composition: 9% Al, 2% Zn, 0.2% Mn, remainder Mg.

Values are plotted as bands in Fig. 1 and 2, with no indication of heat treatment or alloy. When stress concentrations are absent in a simple casting, the alloy and heat treatment are relatively unimportant, obscured by the normal scatter in the test data and the dominating influence of surface finish. In this event, the harder alloys (that is, C alloy and the aged alloys) tend to appear at the top of the scatter bands shown.

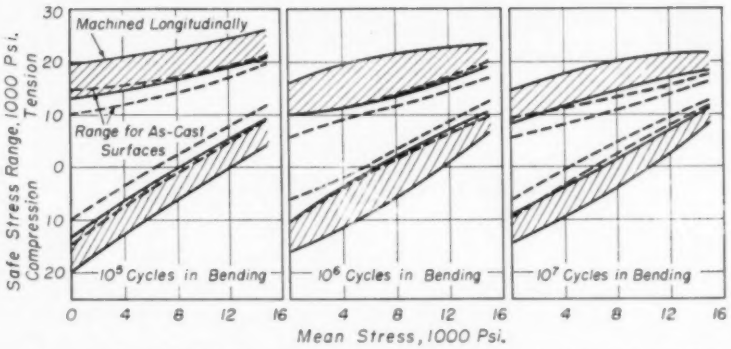

Fig. 1 — Consolidated Data on Endurance of Cast Plates in Alternate Bending With Superimposed Static Bending Stress. Tests made on commercial magnesium alloy castings, heat treated in various ways, and with as-cast surfaces or surfaces machined so tool marks were longitudinal to the imposed stresses

The wider range of safe stresses afforded by machining will give an idea of the effect of normal surface roughness of a sand casting. The sensitivity of metals to stress concentrations at more pronounced notches is also important; such information must be available for static as well as dynamic loading problems. See reference No. 2, as listed on p. 840.

Extensive fatigue data are available on flat test pieces shaped as shown in Fig. 3, wherein the notch effect is intensified progressively by decreasing the fillet radius. The surface finish of the notches is also varied to indicate the relative effects of cast and machined surfaces. The effect of notches of varying degrees in castings is quite apparent from the lines in Fig. 3.

It is expected that the data reviewed to this point can be used by designers, providing cognizance is taken of such factors as the effect of stress raisers, joints, and metallurgical and practical foundry factors encountered in the use of all cast structures. It is now appropriate to consider reasons why these data may be used *quantitatively*.

Endurance Tests on Structures

Initially, rotating beam data on round specimens were solely used for measuring the fatigue properties of magnesium castings.

Observations in the field, where the magnitude of alternating stresses was known, as well as observations in our laboratory testing programs

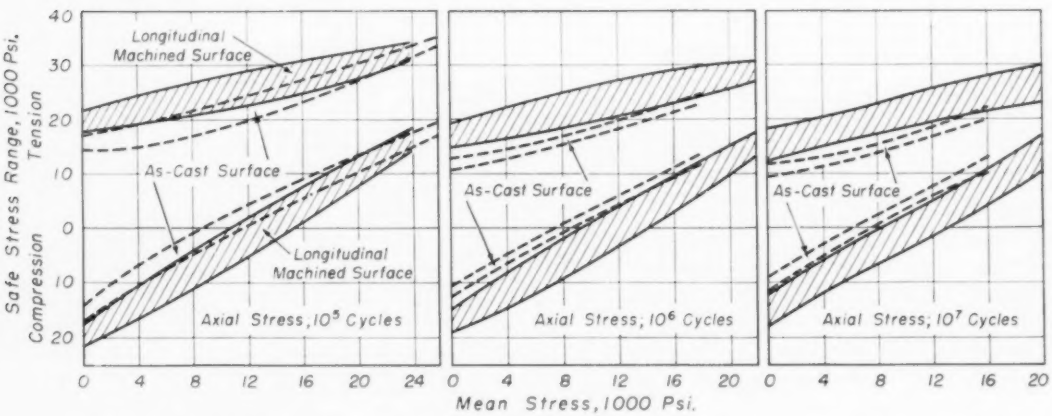

Fig. 2 — Consolidated Information on Endurance of Cast Test Pieces of Rectangular Cross Section, Tested Under Alternating Direct (Axial) Stresses With Superimposed Axial Stress. See also caption of Fig. 1. Fatigue data for magnesium under reversed stresses at elevated temperatures have been published[3]

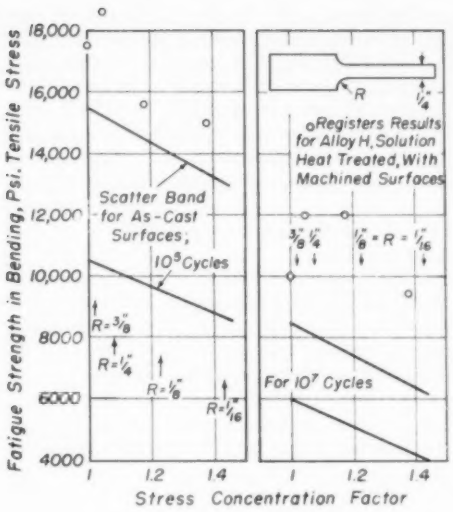

Fig. 3 — Laboratory Tests on As-Cast Magnesium Plates With Radii, Simulating Effect of Fillet notches. Scatter band lines summarize data for various commercial alloys and heat treatments. Sloping lines show effect of fillet notches on safe maximum stress in bending (zero added static stress) for 10^5 and 10^7 cycles respectively. Compare ranges shown at left of the corresponding diagrams of Fig. 1

on actual castings under conditions of fatigue stressing, have shown failures at stresses considerably below the stress values indicated by rotating beam tests. However, tests on H-section castings and large fan blades cast to air foil section (mounted and vibrated similarly to the setup of the hat-section casting in Fig. 4) corresponded within the limit of experimental error (which is about ±500 psi.) to the values obtained in plate bending fatigue tests on sand cast panel specimens[4] (Fig. 1). This is shown in the tabulation at the head of the right-hand column, containing figures for scatter band limits, positive stress, in pure bending:

Correlation of Fatigue Life of Castings and Test Plates

Life	Structural Castings	Cast Plate Test Pieces
10^5 cycles	14,000 to 8,500 psi.	15,000 to 10,000 psi.
10^6 cycles	8,500 to 6,000	10,000 to 6,000

From these tests it may be concluded that plate bending fatigue tests give results which are reliable for indicating safe stress ranges for castings actually in service.

Metallurgical Factors Affecting Fatigue Properties

Studies of failures in service, as well as in tests simulating service, indicate that certain former concepts pertaining to static strength may be entirely misleading when applied to fatigue problems. This is especially true of factors relating to internal metallurgy and to mechanical surface conditions. The static strength of cross sections upon which loads are imposed can be evaluated in terms of the aggregate strength of the entire cross section. Thus, if any zone of weakness exists, the static strength of the cross section can be approximated in terms of the net load-carrying ability of the *remaining* nondefective cross section. On the other hand, the fatigue strength of

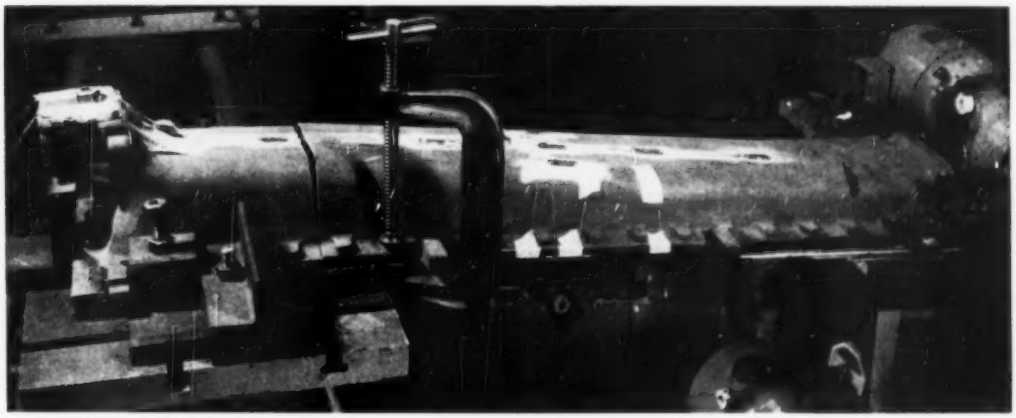

Fig. 4 — Aircraft Engine Casting After Failure in Fatigue Test. Note generous use of wire resistance strain gages

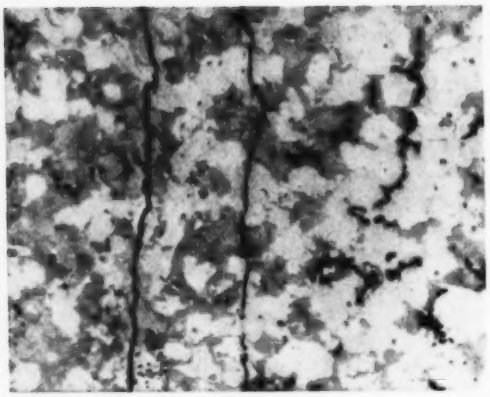

Fig. 5 — Photomicrograph Showing Fatigue Failure Propagating Into a Structure Without Apparent Influence of Regions of Most Concentrated Internal Porosity. Magnified 35×

any cross section is directly related to the strength of the weakest surface area, and this is defined by stress concentrations and metallurgical and mechanical irregularities.

It is the misapplication of considerations based on static strength phenomena that has drawn undue attention to factors which are of relatively minor importance from a dynamic standpoint. These factors include grain size and internal porosity, and they are frequently considered to the exclusion of factors more important to fatigue — such as designed-in stress concentrations, surface quality, and the absolute location of porosity and defects.

Since it is unnecessary to argue the point that fatigue failures start at or very near the surface of an overstressed component and work inward, it is interesting to investigate what influence the condition of the metal *below* the surface may have on the serviceability of the part. Examinations of many service parts have shown repeatedly that failures may occur in uniformly stressed regions through sound areas a small fraction of an inch from areas containing microporosity in various amounts. Figure 5 is a photomicrograph showing a failure which originated at a point only slightly removed from regions of concentrated microporosity located just below the surface.

Laboratory fatigue tests of the cantilever bending type on cast magnesium panels containing microporosity show similar results. With a few random exceptions, failure does not occur through internal microporosity or slight internal defects. When failure does occur through microporosity, it extends to the surface layer.

These observations are not intended to obscure the fact that failures occasionally do proceed through subsurface porosity in uniformly stressed regions in test pieces and machine parts. However, the frequency of these occurrences is completely random and very small compared to the number of instances when failures have been observed to occur at either defective surface regions, or through internal regions metallurgically perfect and slightly offset from internal defects.

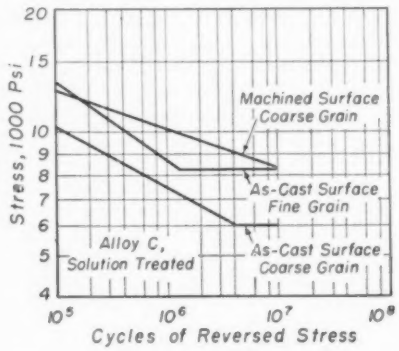

Fig. 6 — Endurance in Bending of Cast Plate Panels of C Alloy (Solution Heat Treated) Having a Normal Fine Grain (0.003 to 0.015 In.) Compared With Coarse-Grained Cast Plates (0.015 to 0.070 In.)

Grain Size — The effect of grain size on fatigue properties is often a point of great concern. In Fig. 6 are shown data indicating that coarse grain sizes of 0.015 to 0.070 in. (in contrast to the range of commercial fine grain sizes of 0.003 to 0.015 in.) result in fatigue properties on the

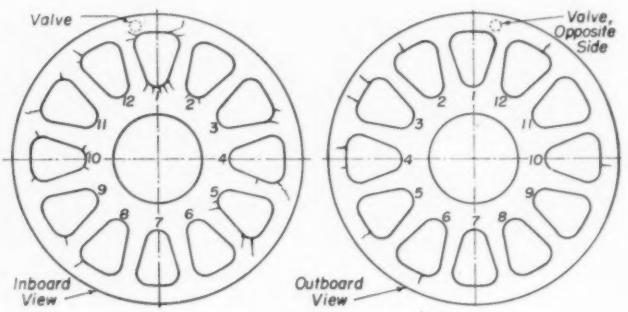

Fig. 7 — Cracks on Inboard and Outboard Sides of Aircraft Wheel After Roll Test

low side of the standard scatter band for castings with as-cast surfaces. (Compare with values for zero mean stress in Fig. 1.) Machining the surfaces masks the effect of grain size by giving general strengthening to castings of any grain size, thus suggesting again that the condition of the surface is more important to fatigue than metallurgical factors, as such.

In this paper, read at the Western Metal Congress in Los Angeles last spring, Mr. Found collects the most recent information on endurance, notch sensitivity and creep of two common magnesium alloys for castings, shows how closely the laboratory tests on relatively small specimens correlate with stresses existing in full-sized parts at failure; further, how to modify preliminary designs so that, like the one-hoss shay, there may be no portion substantially weaker than the rest.

Relative Importance of Design and Metallurgy

Up to this point the discussion has been concerned only with regions of cast metal which have been fairly uniformly stressed. Failures which occur in uniform sections of service parts where design complications are not involved would approximate these conditions.

Now, however, let us superimpose upon the factors just discussed, that of design.[5]

Critical regions in castings usually are at locations of complex design where nonuniform stressing or stress concentrations exist. An ideal example is a certain cast magnesium aircraft landing wheel which, in its early design stage, was roll-tested to failure. Failures occurred in the wheel short of the desired life, at locations shown in the sketch, Fig. 7.

Note the relationship between the locations of cracks. Failures were confined to the fillet regions around the spokes on the inboard side of the wheel, while they fell *between* the fillets on the peripheral side of the spoke windows on the outboard side. Radiographic examinations revealed microporosity in several areas in amounts which approached unacceptability. (This was an early model, and the foundry had not cast a sufficient number to completely solve its porosity problem.) In a few instances the roll-test failures protruded into areas of this porosity, as shown in Fig. 8. In this instance the failure started at the upper edge and worked down as a flat area; it originated in sound metal at the surface and extended into the area of porosity below. The jagged portion was formed when the piece finally broke.

Fig. 8 — Macrosection Through One of the Cracks in Wheel of Fig. 7. Fatigue failure started in sound metal at top; ragged fracture through microporosity was produced by a blow after fatigue test was completed

In appraising this situation, the principal conclusion reached, on the basis of false conceptions about factors affecting fatigue strength and serviceability, would have been that the porosity caused the failure, and if the foundry had made a sound wheel it would have lived up to expectations. Actually, however, the porosity was of minor importance — perhaps even inconsequential. This can be reasoned first from the fact that the porosity is randomly located with respect to the failures; in fact, the failures were oriented with quite a definite relation to the *design* of the wheel. In the second place, previous experience had indicated that internal porosity was secondary to the metallurgical conditions existing at the metal *surface*.

Failure in this wheel, then, was caused only by inadequacies in the *design*, and satisfactory service was had from new wheels after certain design changes had been made.

As a further check on this conclusion a number of segments were cut from a landing wheel of another design and flexed to failure on a plate bending fatigue machine shown in Fig. 9. Failures in this test equipment were close to the location of service fatigue

failures, as shown in the sketch on the S-N diagram, Fig. 10. The amount of microporosity in the various segments was determined by radiography, prior to testing, and the tensile strength at the point of fracture, estimated from these radiographs, varied from 25,000 to 33,000 psi.

The results of the endurance tests are plotted in Fig. 10. The test points exhibit little scatter, despite the variation in porosity. The scatter that does exist bears no relation to the amount of porosity shown in the radiographs.

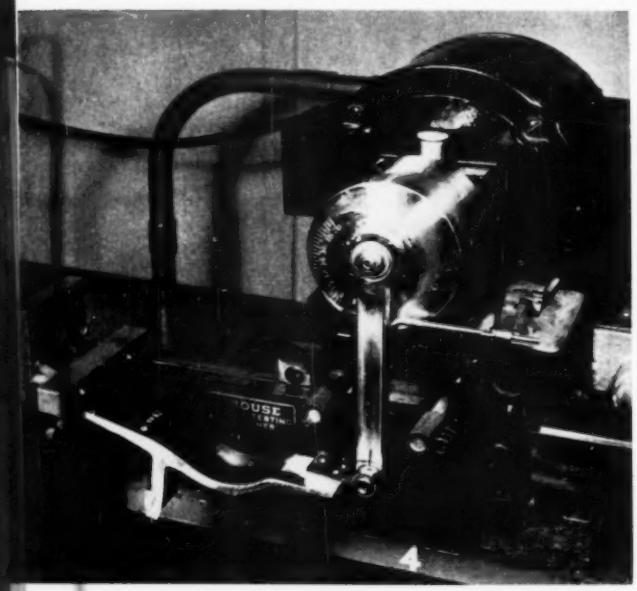

Fig. 9 — Arrangement for Testing Endurance of Wheel Segments

The conclusion is that *subsurface* microporosity has but slight, if any, effect on the bending fatigue properties of magnesium. Whether or not the porosity intersects the surface, rather than the amount present, has a more direct bearing on the fatigue properties. This conclusion is consistent with the attitude that porosity and grain size in magnesium casting are both matters of importance. The relaxation of standards regarding porosity is not implied. Such an action would be without due cognizance of either the detrimental influence of internal porosity on static properties, or of surface porosity on fatigue properties. Furthermore, internal porosity in various sections often is associated with defects at the surface. (The effect of metallurgical quality and design on static properties will be considered subsequently.)

Effect of Surface Working

Standard shot-peening treatments (as applied to steel and other metals) indicate that magnesium does not react to any significant degree. It is apparent from a metallurgical study that the amount of energy necessary to work harden the surface to a favorable depth and degree cannot be obtained from small shot at the usual high velocities. Surface cracking, spalling, and flaking result in the magnesium.

To induce deeper and more extensive cold working we have tried lower velocities with much larger diameter shot ($\frac{3}{16}$-in. steel balls) accelerated to a velocity such that the energy exceeded that

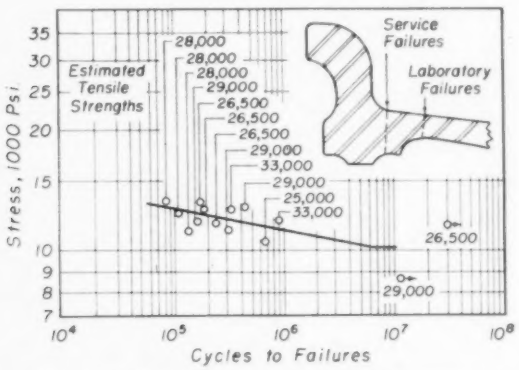

Fig. 10 — Endurance Tests on Wheel Segments Show no Scatter Due to Various Amounts of Microporosity. Tensile strengths are estimated from radiographs. Cyclic stress range: Zero to maximum stress on machined surface. Failures occurred near location of service failures

for conventional small shot. This treatment works the surface for a considerable depth and not only improves the fatigue strength, but also reduces the scatter of tests. Figure 11 shows that fatigue results that would normally define a broader and lower band have been raised and narrowed.

Another treatment that has been developed to induce deeper cold working without cracking is "surface rubbing". ("Surface rubbing" consists of the process of moving a ball-ended tool across the lubricated surface of the metal part at a correct pressure to cause optimum surface deformation. This can be done in either a shaper or a lathe. Speed of the tool is not critical.) Applied to a machined surface this gives very high fatigue properties (see Fig. 11). Both treatments have recently been used on commercial magnesium

castings to advantage. Phenomenal improvements are possible if processors of magnesium castings adopt correct procedures.

Static and Creep Properties

Static design properties for magnesium cast and wrought alloys are available in references No. 6, 7 and 8 on p. 892. How porosity and grain size affect these static properties of cast magnesium alloys has been discussed by Busk and Phillips.[9, 10]

It will be recalled that grain size and internal porosity have an insignificant effect on fatigue properties compared to that of design and surface finish. In contrast to this, the effect of grain size and porosity on the static and impact values is of relatively much larger magnitude. The higher strength materials are most sensitive to porosity. Indeed, losses of 50% in ultimate strength and 80% in impact strength can result from porosity in amounts encountered without foundry control. The most ductile alloys lose ductility by as much as 80% with increasing porosity, whereas the yield strength is not sensitive to nearly the same degree.

Tensile and impact strengths of the common cast magnesium alloys also vary with grain size. Ultimate and yield strengths are reduced about 25% between grain size within the commercial range (0.003 and 0.015 in. average grain diameter) and 0.040 in. Ductility is reduced 30 to 50% between grain sizes within the commercial range and 0.040 in. average diameter. Impact strength is reduced by 50 to 90% with increasing grain size between commercial range and 0.040 in.

However, no service failure has been observed in magnesium castings that can be attributed to grain size variations within the usual commercial range. For practical reasons one might, therefore, ask why grain size control is necessary at all. The answer is in terms of secondary effects important to the foundryman. Fine-grain castings are less liable to hot cracking, fluidity and machinability are improved, and there is a better distribution of intermetallic phases for more effective heat treatments.

The creep properties of magnesium alloys for temperatures up to 600° F. are now available in a form useful for design purposes from the work of J. C. McDonald,[3] from which data for 200° F. are given in Fig. 12. Creep properties, for all practical purposes, are insensitive to porosity and grain size (within commercial limits).

Residual stress measurements[11] have been completed for magnesium, and show they are insignificant from a design standpoint.

In summary, it is apparent that static properties are more sensitive to internal metallurgical factors than are fatigue properties. Despite this, service experiences indicate that the fatigue properties of structures usually are a more critical factor in design.

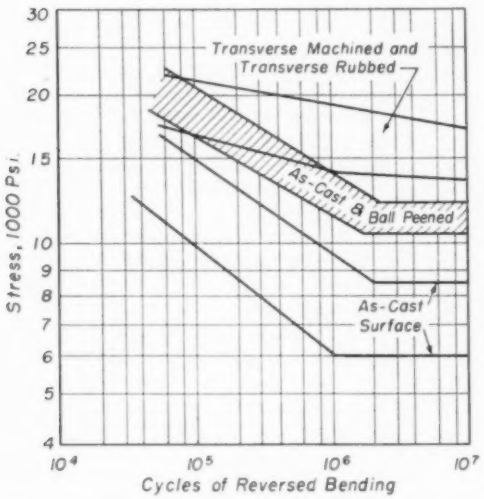

Fig. 11 — Improvement in Endurance of Magnesium Castings (a) by Ball Peening and (b) by Transverse Machining Plus Transverse Rubbing

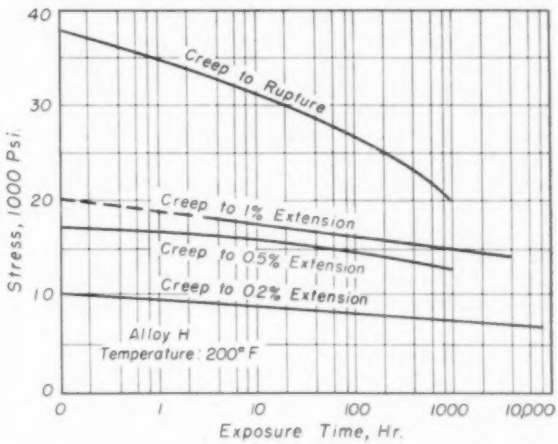

Fig. 12 — Creep of Cast Alloy H (AZ 63; 6% Al, 3% Zn, 0.2% Mn, Remainder Mg) at 200° F., According to McDonald[3]

Designing With Magnesium

When magnesium components are introduced in a structure, the designer must either start with a completely new design (as is usually the case for aircraft components) or start on the basis of the previous design in another metal for which the magnesium component is to be substituted. The latter is frequently the case for commercial uses.

When a new design has to be developed, a satisfactory and efficient design should be arrived at in the least number of steps. Accordingly, the first prototype represents an attempt to match theoretical loading requirements against the known safe static, fatigue, impact or creep strengths of the part.

The methods of experimental stress analysis may then be used on the prototype. Stresses resulting from actual or simulated service loading are measured and are used to correct the theoretical design. The mechanical properties of the metal must be again used to modify the design in the light of the new information. Service trials are usually made during this stage. It is evident that, for castings of critical importance, the number of trial-and-error steps is reduced in proportion as the data describing the material are accurate and the analyses of service performance are informative. Time and expense involved in die and tooling changes and in repeated trials are saved.

When a component has been proven in service in some material other than magnesium, the substitution procedure is quite direct if comprehensive information about the mechanical properties of the previously used material is available.

It is evident that there is a limit to the extent to which design can be based quantitatively on such data as are included in this paper. Structures usually include discontinuities — changes in direction and gage of sections, and junctions of constituent components. One of the advantages of any casting process over wrought metal fabrication is the reduction in numbers of joints. Sections are blended as continuously as possible into each other, thus reducing the number and intensity of stress concentrations ordinarily found in structures fabricated of wrought parts. If the approximate magnitude of the stress concentration is known (either in wrought or cast structures), qualitative comparisons of notch sensitivity between metals can be made for either statically or dynamically loaded stress raisers. This permits materials to be selected on a basis of their notch sensitivity. For either a substitution or an original design, the shapes can be adjusted in the vicinity of stress raisers in accordance with the qualitative relationships shown in the available data.[2, 6]

Consideration must also be given to the modulus of elasticity and the coefficient of thermal expansion.

The modulus of elasticity of magnesium alloys is lower than in the most common structural metals. This should be considered and used to advantage; it is frequently possible thereby to effect a better distribution of load to the principal load-carrying members. Sections of smaller load-carrying ability can then be used than a cursory examination would indicate necessary, and redundant metal eliminated from the structure. Where structural rigidity equivalent to a previous design in steel, for example, is desired, magnesium sections can be increased to provide that rigidity without losing the weight advantage.

The coefficient of thermal expansion is somewhat higher than for the heavier structural metals. Unless this is taken into account, high stresses will be developed leading to creep and distortion.

The data and procedures reviewed in this paper are beyond the academic stage and are now being used by several prominent designers in magnesium — for example, a truck wheel which has been perfected as an original design. The procedure was based on matching experimentally measured service stresses against the fatigue allowable for cast magnesium. An all-magnesium tank trailer is an example of a substitution design in magnesium for steel. The steel design was modified periodically and perfected during years of service. This substitution of magnesium alloys for steel was aided by comparing the available information on fabrication variables and mechanical properties.

These two products, being developed by a prominent wheel manufacturer and a well-known tank firm, are only examples of what can be done to advantage by intelligent engineers.

References

1. "Magnesium Alloy Data Book", The Dow Chemical Co.
2. "The Notch Sensitivity in Fatigue Loading of Some Magnesium-Base and Aluminum-Base Alloys", by G. H. Found, *Proceedings*, American Society for Testing Materials, Vol. 46, 1946, p. 715-734, discussion p. 734-737.
3. "Tensile, Creep, and Fatigue Properties at Elevated Temperatures of Some Magnesium-Base Alloys", by J. C. McDonald, *Proceedings*, American Society for Testing Materials, Vol. 48, 1948.
4. "Fatigue Characteristics of Magnesium Castings", by G. H. Found, "Symposium on Testing Parts and Assemblies", American Society for Testing Materials, 1947, p. 12-22, discussion p. 23-24.

(Continued on p. 892)

MUCH ELECTRICAL MANUFACTURING MAGIC BEGINS HERE

● One of the best known manufacturers of air circuit breakers in the country is the I-T-E Circuit Breaker Company, located at 19th and Hamilton Streets in Philadelphia. From its inception the company has displayed unusual receptiveness to new ideas, whether from within or without; hence it has done its share of pioneering, and perhaps more. Revere is proud to play a part in its progress, through close collaboration with I-T-E engineers, production men, and the purchasing department. The extensive use of Revere Extruded Shapes is but one result of our mutual attack upon I-T-E problems, which the company is good enough to say has saved a great deal of money, as well as made possible a better product . . . Perhaps similar results would be obtained if you gave us the opportunity to place our knowledge as well as our metals at your disposal. Why not inquire?

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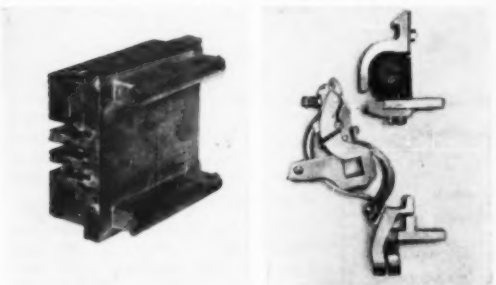
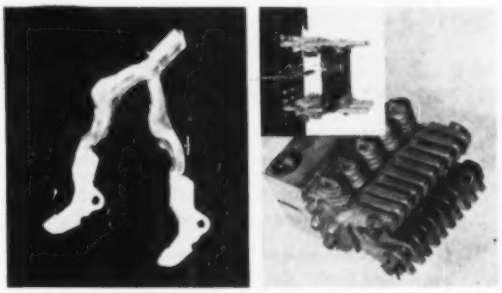
This is but a part of the I-T-E Stock of Revere Extruded Shapes in copper, brass, manganese bronze, and aluminum. I-T-E is a great advocate of extruded shapes, from long experience finding them markedly superior, in uniformity, strength, and economy due to the fact that a great deal of machining is avoided.



(*Left*) I-T-E Contact Block made from an extruded shape. This was formerly extruded in electrolytic copper; changing to Revere Free-Cutting Copper resulted in a saving of 30% in machining time. (*Right*) I-T-E "K" Breaker, Main Contact Assembly in open position. This is an especially interesting assembly, since it shows no less than eight extruded shapes in copper and bronze. Use of these shapes makes the assembly more compact, stronger, lighter, and considerably more economical to produce. The contacts are silver alloy, and the unit is silver plated. . . . In addition to supplying I-T-E with extruded shapes, and strip, Revere furnishes rolls, bar, rod, sheets, in a wide range of non-ferrous alloys, and seamless brass tube.



(*Left*) Main movable Contacts and Flexible Connectors in an I-T-E "K" Type Circuit Breaker. The two contacts are made from Revere Extruded Shapes. Revere and I-T-E collaborated closely on the specifications for the thin-gauge copper strip for the pigtails, working out the correct gauge and temper to avoid notch effects and cracking of the connection at the braze. (*Right*) Main Separable Contacts from an I-T-E Type "LG" Circuit Breaker. These are stamped from Revere Copper Strip with the temper specially controlled to eliminate a de-burring operation previously found necessary to obtain edge surface suitable for electrical contacts. (*Inset*) Back view of "K" type Breaker showing a similar type of contact.

Personals

Adolph W. Machlet, president and treasurer of the American Gas Furnace Co., Elizabeth, N. J., since 1926, has been elevated to chairman of the board of directors. He has been succeeded by **Philip C. Osterman**, who has been associated with the management of the business for the past 45 years.

Jack A. Sartell has accepted a part-time teaching assistantship and is doing graduate work at the University of Minnesota, Minneapolis, Minn.

James W. Kirkpatrick, formerly assistant metallurgical engineer of the H. A. Brassert Co., has joined the Youngstown Sheet and Tube Co., Youngstown, Ohio, as chief metallurgist.

Arthur E. Franks has joined the metals research department of National Research Corp., Cambridge, Mass.

C. L. Clayton, formerly with Columbia Tool Steel Co., has left the steel industry to go into the insurance, building and loan, and real estate business in Hannibal, Mo.

Lloyd J. Bohan, for the past two years a manufacturer's agent in Southern California, has been appointed West Coast representative of the A. F. Holden Co., New Haven, Conn.

Henry E. Frankel has recently accepted a position as research assistant at the Metals Research Laboratory of the Carnegie Institute of Technology, Pittsburgh.

S. S. Gill, formerly with Indian Steel & Wire Products, has been appointed chief metallurgist of the Hindusthan Motors, Ltd., Uttar Para, India.

Lewis S. Bergen has recently been appointed executive assistant to the president of Pullman-Standard Car Mfg. Co., Chicago.

John H. Olson, formerly with the Aluminum Co. of America, is now employed by the Chrysler Corp. in Highland Park, Mich.

The University of Illinois, department of mining and metallurgical engineering, announces the appointment of **Vaughn D. Hildebrandt** as an assistant professor and the promotion of **Robert W. Bohl** to the same rank.

Wayne L. Cockrell is an assistant economic commissioner to the Economic Cooperation Administration in Korea.

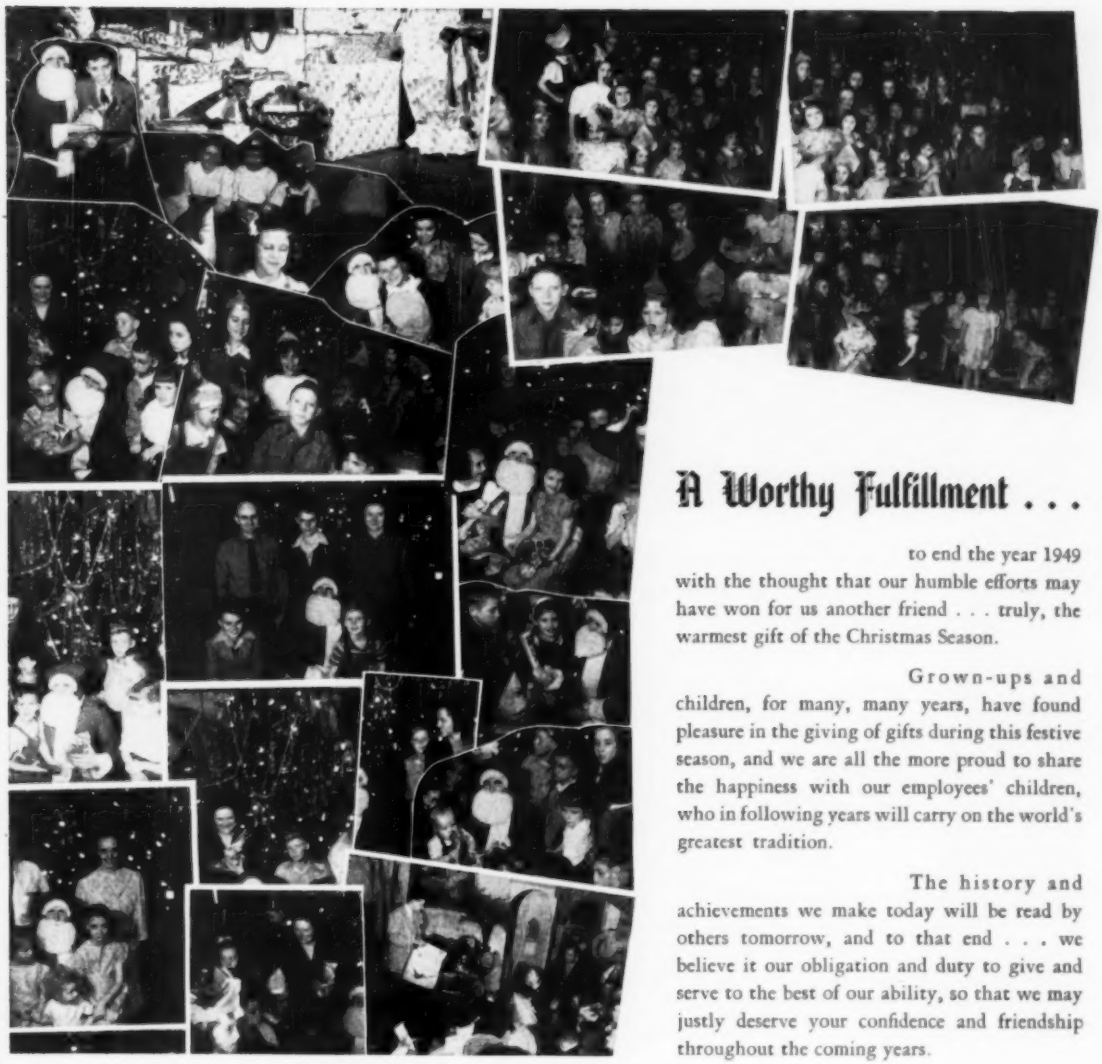
The Ladish Co., Cudahy, Wis., announces the appointment of **Waldemar Naujoks** as special projects engineer.

Firth-Sterling Steel & Carbide Corp. announces the appointment of **T. W. Gabriel** as general sales manager. Mr. Gabriel has been sales manager of the Ohio district since 1944.

Reynolds Metals Co., Louisville, Ky., announces that **E. J. de Ridder**, formerly of I. G. Farben light-metal division and technical assistant to the English Ministry of Supply, has joined its staff of technical service engineers and has been assigned to aluminum design work.

Utah Oil Refinery Co. announces that **H. M. Thomson** has been promoted from assistant chief engineer to chief engineer. He joined the company in 1933.

Youngstown Sheet and Tube Co. announces that **Eugene M. Smith** has joined the company as development engineer for flat rolled products and will be located at the Campbell, Ohio, plant. He was formerly at Battelle Memorial Institute.



(Photos taken at our annual children's Christmas Party)

A Worthy Fulfillment . . .

to end the year 1949 with the thought that our humble efforts may have won for us another friend . . . truly, the warmest gift of the Christmas Season.

Grown-ups and children, for many, many years, have found pleasure in the giving of gifts during this festive season, and we are all the more proud to share the happiness with our employees' children, who in following years will carry on the world's greatest tradition.

The history and achievements we make today will be read by others tomorrow, and to that end . . . we believe it our obligation and duty to give and serve to the best of our ability, so that we may justly deserve your confidence and friendship throughout the coming years.

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Personals

W. S. Lienhardt ⊕, vice-chairman of the Calumet Chapter of the American Society for Metals, has been transferred from general superintendent of the East Chicago, Ind., plant of the Metal and Thermit Corp. to technical assistant to the vice-president in New York City.

Howard D. Wilde, Jr., ⊕ is now research assistant in metallurgy at Pennsylvania State College, State College, Pa.

Howard P. Sharp ⊕ is now working at the Greist Manufacturing Co., New Haven, Conn., in charge of manufacturing methods and time study.

Following graduation from Virginia Polytechnic Institute, **Edgar L. Van Nuis** ⊕ is now working as a junior metallurgist at the research laboratory of the American Smelting and Refining Co., Barber, N. J.

Paul Gordon ⊕, who received his Sc.D. degree from Massachusetts Institute of Technology in September, is now assistant professor of physical metallurgy at Illinois Institute of Technology, Chicago.

After graduating from the University of Michigan in June, **Gerard H. Hilbers, Jr.,** ⊕ has taken a position as metallographer at the Chevrolet Motor Div. laboratories in Detroit.

Mervin T. Rowley ⊕, formerly instructor of metallurgical engineering at Case Institute of Technology, is now employed as assistant chief metallurgist at the Ohio Injector Co., Wadsworth, Ohio.

P. L. Kirsh ⊕ is now at the Rochester, N. Y., branch office of the Fansteel Metallurgical Corp.

Following graduation from Ohio State University in June 1949, **Thomas L. Chase** ⊕ has joined the Columbus, Ohio, branch of Williams & Co., Inc., as a salesman.

John M. Gerken ⊕, who graduated from Rensselaer Polytechnic Institute in January 1949, is now a research fellow at Rensselaer in the metallurgical engineering department.

Emra F. Martin ⊕, who graduated from the University of Tennessee in June 1949, is now with the Great Lakes Carbon Corp., Morganton, N. C., as a technical trainee.

After graduating from Purdue University in June 1949, **William F. Hackett** ⊕ has been employed at Allis-Chalmers Mfg. Co., Milwaukee, on the graduate training course.

Products for the Iron and Steel Industries

PRODUCT	TYPICAL COMPOSITION	APPLICATIONS
ALSIFER	Aluminum.....20% Silicon.....40% Iron.....40%	Used principally as a steel deoxidizer and for grain size control.
FERRO CHROMIUM High Carbon Grade	Chromium....66-70% Carbon.....4-6%	For wrought constructional steels and steel and iron castings.
Iron Foundry Grade	Chromium....62-66% Carbon.....4-6% Silicon.....6-9%	For alloyed cast irons. Readily soluble as a ladle addition at the lower temperatures of cast iron.
Low Carbon Grades	Chromium....67-72% Carbon...06%, .10%, .15%, .20%, .50%, 1.00% and 2.00% max.	For low carbon chromium steels, especially those with high chromium content, such as stainless and heat-resistant types.
FERRO SILICON 25-30% Grade	Silicon.....25-30%	Deoxidizer for open hearth steels; also for high silicon, corrosion-resistant iron castings.
50% Grade	Silicon.....47-52%	Used as a deoxidizer and for the addition of silicon to high silicon steels, for springs, electrical sheets, etc. Pulverized form used as ladle addition to cast irons for silicon content and graphitization control.
75% Grade	Silicon.....74-79%	For high content silicon steels, such as spring steels, sheets and forgings of high magnetic qualities for electrical apparatus.
High Silicon Grades 80-85% 85-90% 90-95%	 Silicon.....80-84.9% Silicon.....85-89.9% Silicon.....90-95%	 For high content silicon steels where small ladle additions are used for required silicon content. Also for manufacture of hydrogen by reaction with caustic soda and production of magnesium by the Pidgeon process.
FERRO TITANIUM High Carbon Grade	Titanium.....15-18% Carbon.....6-8%	Final ladle addition to control "rimming" action and to clean effervescing steel. Final deoxidizer and scavenger for steel castings and fully killed ingot steels.
Medium Carbon Grade	Titanium.....17-21% Carbon.....3-4.50%	Often preferred to the High Carbon Grade as a final ladle addition to very low carbon rimming or effervescing steels.
Low Carbon Grades 20-25% Ti Grade	Titanium.....20-25% Carbon...max. 0.10% Silicon.....max. 4% Aluminum max. 3.50%	Carbide stabilizer in high chromium corrosion-resistant steels of extremely low aluminum content. Deoxidizer for some casting and forging steels.
40% Ti Grade	Titanium.....38-43% Carbon...max. 0.10% Silicon.....max. 4% Aluminum...max. 8%	Carbide stabilizer in high chromium corrosion-resistant steels, where smaller ladle additions are desired and extremely low aluminum content is not essential.
ALUMINUM	Aluminum ... 85-99%	For deoxidation and grain size control of steel. (Ingot, shot, grain and special shapes.)
VANADIUM METAL 90% Grade 95% Grade 99.7% Grade	 Vanadium ..... 91% Vanadium ..... 95% Vanadium 99.7%	For iron-free, low-iron, or low-impurity alloys.

PRODUCT	TYPICAL COMPOSITION	APPLICATIONS
FERRO VANADIUM Iron Foundry Grade	Vanadium....38-42% Silicon.....7-11% Carbon.....about 1%	For iron foundry use. Imparts remarkable improvement in physical properties with no sacrifice of machinability; highly soluble, insuring complete diffusion.
Grade "A" (Open Hearth)	Vanadium...35-45% 50-55% Silicon...max. 7.50% Carbon...max. 3.00%	For low percentage vanadium content of rolled, forged or cast constructional steels. Also used in vanadium cast irons.
Grade "B" (Crucible)	Vanadium...35-45% 50-55% Silicon...max. 3.50% Carbon...max. 0.50%	For tool steels and special high vanadium steels in which required limits for carbon and silicon are narrow.
Grade "C" (Primos)	Vanadium...35-45% 50-55% 70-80% Silicon...max. 1.25% Carbon...max. 0.20%	For tool steels and special steels requiring high percentages of vanadium and exceptionally low carbon and silicon content.
VANADIUM PENTOXIDE Technical Grade Fused Form	V_2O_5..88-92%	A source of vanadium in basic electric furnace steels. A base for numerous chemical compounds.
Technical Grade Air Dried Form	V_2O_5.....83-85%	A base for preparation of numerous chemical compounds (catalysts, etc.).
GRAINAL ALLOYS Vanadium Grainal No. 1	Vanadium....25.00% Aluminum....10.00% Titanium.....15.00% Boron.....0.20%	Practical and economical intensifiers for controlling and increasing the capacity of steels to harden, and for improving other important engineering and physical properties.
Vanadium Grainal No. 6	Vanadium....13.00% Aluminum....12.00% Titanium.....20.00% Boron.....0.20%	See above.
Grainal No. 79	Aluminum....13.00% Titanium.....20.00% Zirconium.....4.00% Manganese....8.00% Boron.....0.50% Silicon.....5.00%	See above.
GRAPHIDOX No. 4	Silicon.....48-52% Titanium.....9-11% Calcium.....5-7%	For graphitization of iron; ladle treatment insures normal graphite, free from dentritic structure; reduces chill; efficient inoculant in production of high strength irons.
V-FOUNDRY ALLOYS V-5 Grade	Chromium....38-42% Silicon.....17-19% Manganese....8-11%	Used in cast irons as a ladle addition. Reduces chill, promotes uniformity of structure, increases strength and hardness.
V-7 Grade	Chromium....28-32% Silicon.....15-21% Manganese...14-16%	See above.
BRIQUETTES Ferro Chromium	Hexagonal. Weigh approx. 3⅜ lb. and contain 2 lb. of chromium.	A practical and convenient form for adding ferro-alloys to the cupola.
Ferro Silicon	Two sizes, both cylindrical, one containing 1 lb. of silicon; the other, 2 lb. of silicon.	See above.
MISCELLANEOUS	Special ferro-alloys, metals, chemicals and carbides.	To meet individual requirements.

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Personals

William C. Leslie, who received his Ph.D. in metallurgy from Ohio State University in September 1949, is now employed as metallurgist at the U. S. Steel Corp., Research Laboratory, Kearny, N. J.

Arthur A. Conrad, Jr., has been transferred by the U. S. Steel Corp. from the Lorain works of the National Tube Co. to the Research Laboratory in Kearny, N. J., for training in research.

Conrad C. Wissmann, formerly metallurgist for the Los Angeles Steel Casting Co., is now research metallurgist for Solar Aircraft Co., San Diego, Calif.

Robert G. Piper is now employed as a junior metallurgist at the Standard Steel Works, Burnham, Pa.

Reginald W. Hoagland, formerly with the Budd Co. in the patent department and Budd's Red Lion Plant in charge of standardization of rail car design, has opened his own office as a patent attorney in Flint, Mich.

Charles E. Lundin, Jr., is now a research assistant at the Armour Research Foundation of the Illinois Institute of Technology, Chicago.

Lester E. Wilensky, who graduated from Rensselaer Polytechnic Institute in June 1949, is now working in the process development division of the magnesium laboratories of the Dow Chemical Co., Midland, Mich.

Raymond L. Phebus, formerly with the research laboratory of Dr. Carl Zapffe, in Baltimore, Md., is now a research assistant and part-time graduate student in the department of metallurgy of the University of Pennsylvania, Philadelphia.

Following graduation from Carnegie Institute of Technology, **Michael Hrees, Jr.,** has accepted employment at the Vandergrift, Pa., plant of the Carnegie-Illinois Steel Corp. as a process engineer.

William M. Coody, who received his B.S. in metallurgical engineering from the University of Alabama in August, has accepted a position with Tennessee Coal, Iron and R.R. Co. as a student observer in the metallurgical department.

Robert F. Warner is now working for the University of California as a research assistant in mechanical engineering at the Los Alamos, N. M., Atomic Energy Laboratory.

Personals

Ray E. DeCamp is now chief mechanical engineer at Consolidated Western Steel Corp., Los Angeles.

After graduating from Purdue University, **Bruce D. Gribben** is now employed by the Delco-Remy Division of General Motors Corp.

Edward J. Rock, Jr., a June graduate from the South Dakota School of Mines and Technology, is at the present time working as a sand technician at Fairbanks, Morse & Co., Beloit, Wis.

After graduating from the University of Illinois in June 1949, **Daniel R. Demeter** was employed as a metallurgist at Youngstown Sheet and Tube Co., East Chicago, Ind.

Spencer R. Griffiths has been appointed assistant sales manager of Unistrut Products Co., Chicago. He was formerly in charge of stainless steel sales in the Midwest district for Joseph T. Ryerson & Son, Inc.

Saul Gilbert, who graduated from the school of mines of the University of Pittsburgh recently, is now a research assistant at the Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh.

H. T. Sumsion, who recently received his Ph.D. from the University of Utah, has been appointed senior research engineer in the research department of the Carborundum Co., Niagara Falls, N. Y.

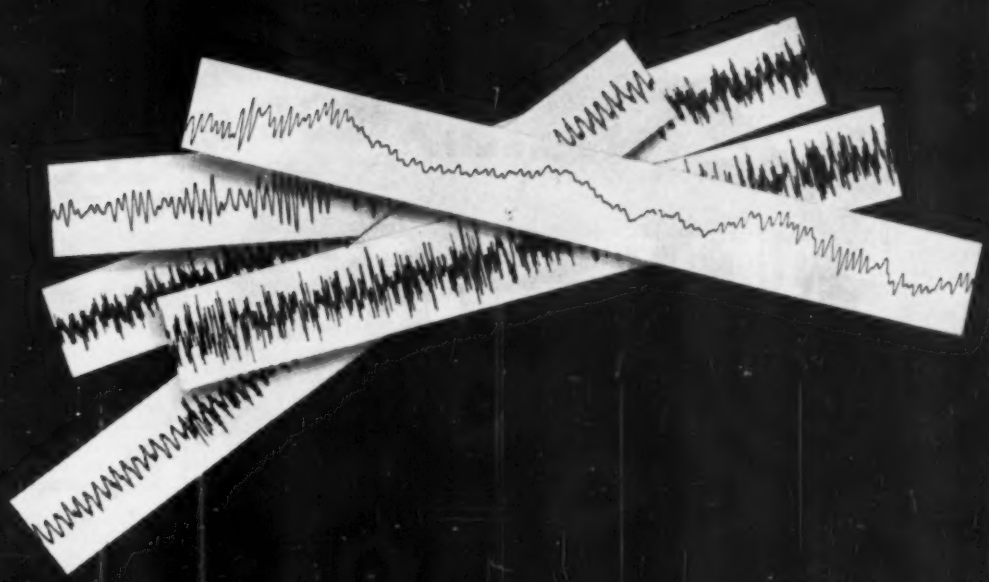
Tien-Shih Liu, who obtained his M.S. in metallurgical engineering from Missouri School of Mines in May 1949, is now working toward his Ph.D. at the University of Notre Dame, Notre Dame, Ind.

Robert H. Grace, formerly process development supervisor of Remington Arms Co., has joined the L. S. Starrett Co., Athol, Mass., as metallurgist.

Aaron J. Keeperman, a recent graduate of Pratt Institute, is now employed in the production department of the Silent Hoist & Crane Co., Brooklyn, N. Y.

Formerly research and development engineer of Columbus McKinnon Chain Corp., **William H. Britt** is now chief engineer of Columbia Mills, Inc., Syracuse, N. Y.

Joseph R. Powell, formerly with General Electric Co. and Scovill Mfg. Co., has been appointed chemist in the plating department, A. S. Campbell Co., East Boston, Mass.



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Personals

Charles A. Davis, charter member, past chairman and a past director of the Peoria Chapter, formerly with the Caterpillar Tractor Co. as a development engineer, is now manager of product development at La Salle Steel Co., Chicago.

M. F. White, formerly president and chief engineer with Electronic Process Induction Co., Inc., is now chief engineer of Induction Heat Service Co., New York City.

Paul J. McKimm is now a production and metallurgical consultant to the steel industry with offices in Cleveland. He was formerly with Otis Steel Co., Wheeling Steel Corp. and Youngstown Sheet and Tube Co.

J. G. Cametti has been transferred from the East Pittsburgh plant of Westinghouse Electric Corp. to the Aviation Gas Turbine Div. of Westinghouse in Kansas City, where he will set up and direct precision casting facilities in the jet engine plant.

Following the award of his Ph.D in metallurgy from Ohio State University, **Harold M. McCullough** has accepted a position with Sylvania Electric Products, Inc., as a research metallurgist in its laboratories at Bayside, L. I., N. Y.

Martin S. Maier, formerly with Eastman Kodak Co., is now associated with the U. S. Asbestos Div., Raybestos-Manhattan, Inc., Manheim, Pa., as head of the physics division in the research and development laboratory.

After receiving an M.S. in metallurgy from the University of Utah in June, **Robert E. Hagen** joined the research laboratory of the Oliver Iron Mining Co. as an assistant concentration engineer.

Donald P. Beaver is now metallurgist for Manual T. Fine & Co., Los Angeles, steel and aluminum warehouse.

After graduating from Penn College, **Walter L. Gage** has joined the Kennecott Copper Corp. as a smelter sampler of the Chino Mines Div., Hurley, N. M.

Following graduation from Michigan College of Mining and Technology, **Russell W. Burman** has accepted employment with the Caterpillar Tractor Co., Peoria, Ill., as a trainee.

Calvin C. Enderlin is now employed as metallurgist for the Pacific Can Co., San Francisco.

GENERAL ELECTRIC FURNACE SAVES BETTER THAN 30% ON OPERATING COST

AS REPORTED IN

Electrified INDUSTRY*

"Better than 30% saving on operating cost, rejects cut to a minimum, greatly improved working conditions and quality of product are all attributed to the use of a roller hearth electric furnace for cleaning hollow ware prior to enameling. This new and revolutionary method being used by the Republic Stamping and Enameling Company in Canton, Ohio, bright anneals the parts to produce clean, bright surfaces resembling aluminum. Stresses due to forming and welding are gone, original grain structure is restored, and blue-oxide from spot welds has disappeared with the new process."

*"New Cleaning Method for Hollow Ware Has Many Advantages" in ELECTRIFIED INDUSTRY, March, 1949.

General Electric builds electric furnaces and associated equipment for practically every industrial heat-treating process. For more information on G-E furnaces or on G-E induction or dielectric heating equipment, consult the nearest G-E Apparatus Sales Office; or write to: *Apparatus Dept., Sect. 720-10, General Electric Company, Schenectady 5, N. Y.*

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GENERAL ELECTRIC

Personals

E. R. Craig is now assistant superintendent of the sheet division, Continental Steel Corp., Kokomo, Ind.

W. H. Mathesius, previously assistant superintendent of the open-hearth and foundry departments, Geneva Steel Co., is now assistant to the manager of operations, LaClede Christy Co., St. Louis, Mo.

Following graduation from Marquette Engineering College and Harvard Law School, **Donald A. Doheny** has become associated with the law firm of Igoe, Carroll & Keefe, St. Louis, Mo.

Harold E. Cartier is now general supervisor in the engineering process development department of A.C. Spark Plug Div. of the General Motors Corp.

Eugene L. Bulgozdy is now teaching at Washington State College, Pullman, Wash., while working toward his M.S. in inorganic chemistry.

Bernard S. Lement, formerly on the research staff of the department of metallurgy, Massachusetts Institute of Technology, has recently been made assistant professor of metallurgy at the University of Notre Dame, Notre Dame, Ind.

W. Kenneth Bodger has recently become associate professor of mechanical engineering at Case Institute of Technology, Cleveland, Ohio. Mr. Bodger was previously with Pratt & Whitney Aircraft, the Elliott Co., Air Preheater Corp., and most recently had a consulting practice, which he will continue to maintain.

David B. Magy has enrolled as a student in dentistry at the University of California School of Dentistry.

H. A. Cavanagh is now sales engineer for the Vanadium-Alloys Steel Co., Chicago.

Following graduation from Michigan College of Mining and Technology, **Joseph J. Broecker** has joined the foundry training program of J. I. Case Co., Racine, Wis.

Saban S. Erdinc, who graduated from the Colorado School of Mines in July 1949, is now attending the Ohio State University, Columbus, Ohio.

F. Keith Lampson is a junior metallurgist in the mechanical metallurgy section at the NEPA Division of Fairchild Engine & Airplane Corp., Oak Ridge, Tenn.

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To remove thermometers, simply raise end of box platform.

Thermometers readily slide in or out of spacing retainers.

TAG—oldest name in the business, with its new **WESTON** affiliation and new, modern plant, now reasserts its leadership in the field. Makers of the highest grade thermometers since 1769, TAG is *first* to develop this unique, improved thermometer packaging*. The compact, handy design means new convenience, less cumbersome handling for you. Result: reduced breakage, faster inspection, easier testing and uniform stocking.

Complete specifications on each box label. Available in lots of three or six to a box. Comprehensive stocks. Order from your laboratory supply dealer, or direct from us. Catalog 1100 lists and describes the complete line of TAG Thermometers and Hydrometers and contains useful Fahrenheit-Centigrade conversion tables. Just write for it.

*Patent Pending

C. J. Tagliabue Corporation (N. J.)

Subsidiary of WESTON ELECTRICAL INSTRUMENT CORPORATION

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TAG

Personals

J. F. Barns is now supervisor of industrial sales of the Barrett Division of Allied Chemical & Dye Corp., New York City.

Donald E. Grimm, a 1949 graduate of Michigan College of Mining and Technology, has accepted a position as research assistant at Los Alamos Scientific Laboratory, Los Alamos, N. M.

W. C. Paynton is now a research engineer with the metallurgical project of Massachusetts Institute of Technology, Cambridge, Mass.

Johnathan W. Whitmer, a June 1949 graduate of the University of Kentucky, is now a metallurgist in the welding section of the Bayonne, N. J., Research Laboratory of the International Nickel Co.

John M. Keyes was transferred from the technical department of the Wolverine Tube Div. in Detroit to the new seamless tube mill at Decatur, Ala., where he will be senior metallurgist and supervisor of the plant technical department.

John E. Larson has been appointed plant superintendent of the McCook, Ill., sheet mill of the Reynolds Metals Co.

W. F. Chase, formerly of the faculty of the department of mechanical engineering at the University of Wisconsin, has accepted a position as instructor in mechanical engineering at the University of Detroit.

The Gulf Oil Corp. has transferred **Robert A. Fitch** to its general office in Pittsburgh where he will be chief fuels and lubricants engineer in the metallurgical section of the industrial products engineering department. He has been with Gulf's New York division as industrial sales engineer for 16 years.

William K. Stamets, Jr., formerly on the faculty of Cornell University, has opened an office in Seattle, Wash., for consultation on machine design and related problems.

Geo. J. Jameson has been transferred from the technical group, Naval Supply Depot, Clearfield, Ogden, Utah, to the inspection division of the Seattle, Wash., Supply Center, Bureau of Federal Supply.

Willard H. Hawley, Jr., graduated from Virginia Polytechnic Institute last June and is now taking graduate work in metallurgy at Yale University, New Haven, Conn.

Personals

Jachin M. Forbes has accepted an appointment as a commodity specialist in the ferrous section of the metals economics branch of the Bureau of Mines, Washington, D. C.

Upon graduation from the University of Wisconsin in June 1949, **Arnold D. Arnaut** joined the physics laboratories of Sylvania Electric Products, Inc., Bayside, N. Y.

J. F. Lobach has recently completed the training course of Bethlehem Steel Co.'s fabricated steel construction division and is now a salesman in the Philadelphia office.

Joseph P. Hammond, formerly at Battelle Memorial Institute, is now an assistant professor of metallurgical engineering in the mining and metallurgical engineering department at the University of Kentucky, Lexington, Ky.

J. E. Jackson, formerly general superintendent of Wayne Pump Co., Ft. Wayne, Ind., has opened a new business in Cleveland, named the Jackson Tool Supply Co.

After graduating from Yale University in June 1949 with a doctor of engineering degree, **Raymond W. Fenn, Jr.**, has accepted a position in the research and development group in the magnesium division of the Dow Chemical Co., Midland, Mich.

Joseph N. Moorhead has retired from the Aluminum Co. of America and will set up a consulting service in Buffalo, N. Y., in the field of light metals. Mr. Moorhead was with Alcoa for 32 years.

E. M. Wallace is now president and manager of the Wallace Mfg. Corp., West Springfield, Mass.

Gordon Shaw, formerly with the Canadian White Pine Co. of Vancouver, is now manager of Frank & Co., Ukiah, Calif.

George Sachs has resigned from his position as director of the Indian National Metallurgical Laboratory, and is now president of Metals Research Associates of Cleveland, consultants in research, development and plant improvement in the fields of casting, metal fabricating and heat treating. In this new venture he will be associated with **Harry P. Croft**, trustee; **C. F. Prutton**, consultant; **George B. Espey**, metallurgist, and **Lee Wilson**, president, Lee Wilson Engineering Co.

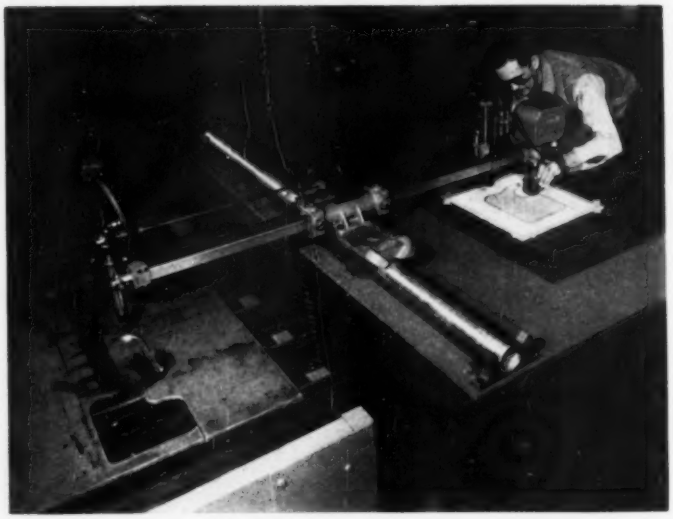
ENGINEERING DIGEST OF NEW PRODUCTS

SHAPE-CUTTING MACHINE: A new portable, oxyacetylene, shape-cutting machine, the Airco No. 3 Monograph, is announced by Air Reduction Sales Company.

The Monograph will cut steel up to eight inches in thickness, in any shape within a 54 in. by 32 in. area, at speeds ranging from 3 to 30 inches per minute. The length of the cutting area can be extended by adding tubular rail extensions. This machine will also handle straight-line, circle and bevel cutting jobs with a high degree of accuracy.

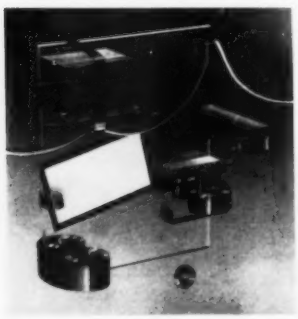
The Monograph weighs only 110 lbs., the tubular rail an additional 35 lbs., making a truly portable machine that can easily be transported from shop to shop or to the work. The entire unit is packed in a sturdy carrying case that can be conveniently handled by two men and stored in a 7 ft. by 1½ ft. space.

For further information circle inquiry card number 956.



COIL-TYPE CLAMP: A new and unique industrial clamp for maintenance, production, laboratory and display use throughout industry has been developed by the Hunter Spring Co.

It possesses six notable characteristics — (1) automatic take-up, (2) constant clamping pressure regardless of the thickness of the object held, (3) enormous dimensional range between clamp heads, (4) full clamping pressure inherent in single part (without externally applied forces), (5) extreme flexibility in locating clamping pressures (head pressures need not always be opposed), and (6) coil-form heads or jaws (can act as cord or tubing guides or as a base for freely supporting the clamped object).



Currently available standard sizes cover a range of clamping pressures from 2 oz. to 20 lb. in 8 increments. In breadth they range from ¼ in. to 2 in. Special pressures and sizes are available upon a development basis.

For further information circle inquiry card number 957.

NEW ALLOY: A new magnesium-ferrosilicon alloy that promotes the formation of nodular graphite in cast iron is now available from the Electro Metallurgical Division of Union Carbide and Carbon Corp. The alloy contains about 7 to 10% magnesium, approximately 43% silicon, and the balance chiefly iron, and is available in a standard size of ⅜ in. by down.

Nodular iron castings are exceptionally strong and ductile, and show promise of giving economical service in many applications. Results of a large number of tests indicate that the hazards of a magnesium addition are minimized when this magnesium-ferrosilicon alloy is used to produce nodular iron. Since the alloy acts both as a nodulizing and an inoculating agent, often only one ladle addition is required for the production of ductile iron castings. Moreover, magnesium recoveries have been found to be comparatively high.

For further information circle inquiry card number 958.

NEW MOLD STEEL: The Carpenter Steel Company announces a new steel for plastic mold cavities and force plugs which offers the moldmaker an unusual combination of properties.

It is claimed that with the new steel many intricate mold shapes can be hobbed in one operation, deeper impressions can be pushed with present equipment, and more accurate reproduction of hob design is possible. Samson Extra has a maximum Brinell hardness of about 105. In a test to determine hobbing qualities, a mold blank 1.75 in. in dia. by 2.25 in. lg. was used. A hob measuring .910 in. in dia. tapered .045 in. per in. was sunk into the mold blank using a load of 110 tons with one push. A depth of cavity measuring .71 in. was obtained. Assurance of a clean sound mold cavity is guaranteed by 100% acid disc inspection of the steel.

Field tests show that mold cavities made from new steel have unusually high strength and resistance to sinking, because the yield strength of the steel when oil quenched is double the 38,000 psi of a good grade of hobbing iron.

Although the new steel is annealed for easiest hobbing, and is therefore soft, it machines very satisfactorily because of its unique analysis and control in manufacture.

For further information circle inquiry card number 959.

BEAT GALVANIC CORROSION WITH

Alcoa Aluminum Fasteners

No weakened joints or wobbly assemblies when you fasten aluminum with Alcoa Aluminum Fasteners! They prevent the galvanic corrosion that can result when dissimilar metals are used to fasten aluminum; resist common corrosion, too—will never red rust-streak your product. Costs are surprisingly low.

Alcoa Fasteners are available from stock with Phillips head for fast power driving, or slotted heads; in sheet metal, wood and machine screws; standard threads in all popular sizes; hex head bolts and nuts; cap, castle and wing nuts; washers, solid or tubular rivets, and cotter pins.

Investigate the low cost and sales advantages of aluminum fasteners today! Write on your letterhead for free samples, specifying the types you'd like, to: ALUMINUM COMPANY OF AMERICA, 2101M Gulf Building, Pittsburgh 19, Pennsylvania.

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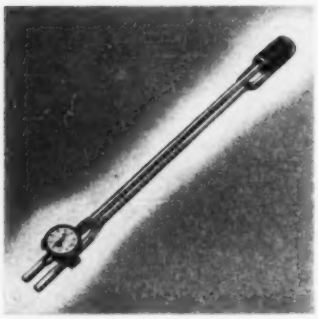
ALCOA *Aluminum* FASTENERS

Other Alcoa Products: INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS IMPACT EXTRUSIONS • ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

ENGINEERING DIGEST OF NEW PRODUCTS

EXPANSIOMETER: The measurement of thermal expansion in metals can be made with ease and accuracy using the new Expansiometer offered by the Harry W. Dietert Company.



The entire Expansiometer is constructed of fused quartz with a sensitive dial indicator attached. Samples may be up to 1⅛ in. diameter and 3 in. long. Measurements at temperatures up to 2500° F. are obtained by inserting the Expansiometer horizontally into any suitable furnace.

For further information circle inquiry card number 960.

SELF-CENTERING PILOT PROJECTION WELD NUT: A new type pilot projection weld nut has been designed by the Grip Nut Co., for quick and easy positioning or centering at the spot where it is to be welded to the metal.

Gripco Weld Nuts are used where application is difficult, due to restricted space or where metal sections are too thin to thread. The application process is reversed, the nuts being welded into final position and the bolt screwed into the nut. Weld nuts are also attached to various bulky or heavy products, so they can be bolted securely against shifting in transit.

For further information circle inquiry card number 961.

PORTABLE SPOT WELDER: A portable spot welder is now being marketed by the Welderon Co. Designed to be brought right to the job, the Welderon can be plugged into any 115-volt, 60-cycle, 25-amp. current outlet. The new unit is fitted with three current taps for spot welding metals up to a combined thickness of ⅛ in.

For further information circle inquiry card number 962.

ENGINEERING DIGEST OF NEW PRODUCTS

TWO-MINUTE ANALYSIS OF STAINLESS & TOOL STEELS: A direct reading method of analysis for stainless steels has been developed by Applied Research Laboratories. This equipment is equivalent in accuracy, in every respect, to present routine chemical methods. The total time of analysis for all metallic elements is two to three minutes, including sample preparation. Duplicate analysis on a single sample for these constituents can be made in a total time of only three to four minutes.

The precision attained for chromium and nickel is much higher than has ever been reported for any spectrochemical system. A variety of rolled and cast samples repeatedly provided standard deviations from 0.3 to 0.4 percent of the quantity measured.

The equipment utilized consists of a two-meter spectrometer, a recording console and a multisource.

For further information circle inquiry card number 963.

STAINLESS STEEL: An unusual combination of advantages is provided in a new grade of stainless steel called Armco 17-4 PH, produced by Armco Steel Corp. This alloy has high hardness and strength, excellent corrosion resistance, good fabrication characteristics, and requires only a low temperature hardening treatment (850 to 1000° F.) It is recommended especially for gears, cams, shafting, chains, valves and pump parts in equipment where high mechanical properties and corrosion resistance better than can be obtained with present standard hardenable grades are necessary. A wide range of possible applications for this alloy is indicated.

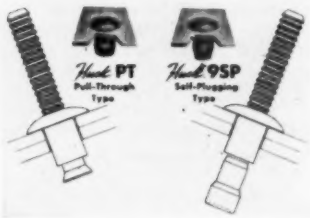
Containing 17% chromium, 4% nickel and 4% copper, Armco 17-4 PH stainless steel has a corrosion resistance superior to that of the standard hardenable alloys and approaching that of 18-8. Hardness values of Rockwell C-40 to 45, with high tensile and yield strength, are obtained by precipitation hardening. This merely requires heating the annealed material to approximately 900° F., instead of the high temperatures used with standard hardenable stainless steels, eliminates problems such as quench cracks, distortion, internal stresses and objectionable scaling. Since only an easily removed surface discoloration is produced in the precipitation hardening of Armco 17-4 PH stainless steel, parts can be finish machined before hardening. This eliminates expensive grinding or finish machining normally required after heat treatment.

For further information circle inquiry card number 964.

ENGINEERING DIGEST OF NEW PRODUCTS

BLIND RIVETS: Two new blind rivets announced by Huck Manufacturing Company are designed as Huck PT pull-through type and Huck 9SP self-plugging type. Both types are available in 1⅛ in., ⅜ in., ⅝ in., and ¼ in. diameter. Both are regularly furnished in aluminum alloys or cadmium-plated mild steel, with brazier or 100° countersunk heads.

Huck pull-through type blind rivets have no minimum grip limitation, and the Huck 9SP self-plugging type blind rivets have a grip range of .140 in. for any grip increment. In addition, positive shank expansion provides ample hole-filling to meet all normal requirements. Special engineering features prevent splitting of the sleeve during formation of the blind head.



The pin tail of the rivet is provided with pull grooves to assure positive driving. The rivets are inserted in the gun or hole with equal ease. Once inserted in the gun, they cannot wobble, fall out, or move to cause improperly-driven rivets. These features are particularly helpful in riveting hard-to-reach or overhead holes. The pulling section will not break off prematurely in driving.

The pin tail is automatically ejected by the next rivet and cannot become jammed in the driving gun.

These rivets are driven by a single operator with a manual or pneumatic pull gun, and require access to only one side of the work. The gun requires no adjustment for grip length; and adaptors permit using other pneumatic pull guns.

For further information circle inquiry card number 965.

AIR DRAW MUFFLE FURNACE: An air draw muffle furnace with temperatures to 1250° F. has been developed by Hevi Duty Electric Company.

This new furnace provides a means for rapid and uniform heating of metals and other materials. While its primary application is the tempering or drawing of tool and die steels, it may be used for practically any heating operation requiring temperatures to 1250° F.

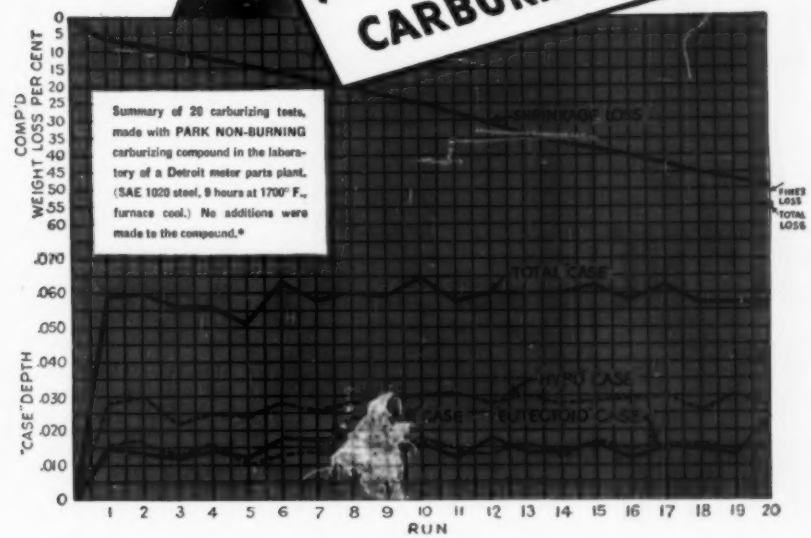
For further information circle inquiry card number 966.

NEW CAST IRON: Industry now has available to it a new cast iron which, unlike ordinary cast iron, is not brittle but can be bent or twisted. This new cast iron was developed in the research laboratories of The International Nickel Company, Inc. This astounding new material can be made readily and economically and can be used in a myriad of applications, thus affording countless economies throughout the industrial world. The novel product, popularly known as ductile cast iron, has several times greater strength than ordinary cast iron with greatly increased ductility and shock-resistance.

This new ductile cast iron combines processing advantages of cast iron, such as fluidity, castability and machinability, with many of the product advantages of steel. The essential feature of the inventions is the introduction into and retention by the molten iron under treatment of a small but effective amount of magnesium. The presence of critical amounts of magnesium in the novel cast iron produces a new graphite structure which is in the form of spheroids or compacted particles. Due to the elimination of a substantial amount of the usual weakening flake graphite, the new magnesium-treated cast iron possesses excellent engineering properties, particularly high tensile strength, elastic modulus, yield strength, toughness and ductility. Under stress, it behaves elastically like steel rather than like cast iron, having proportionality of strain to stress up to high loads with a modulus of elasticity of about 25 million pounds per square inch.

For further information circle inquiry card number 967.

TESTS PROVE LOW SHRINKAGE OF... Park NON-BURNING CARBURIZERS



YOU CAN CUT your consumption of carburizing compound up to 50% by using PARK NON-BURNING pack-carburizers. Shrinkage losses are low and carburizing activity is maintained by additions of as low as 1 to 12. Moreover, these materials are ideal for direct quenching because they do not burn after removal from the furnace.

CASE DEPTHS furnished by PARK NON-BURNING carburizing compounds are consistent with steels' ability to absorb carbon during any given time-temperature cycle. In addition, undesirable carbon build up at steel surfaces is prevented, particularly on alloy steels. Surface carbon concentrations rarely exceed 1% with conventional carburizing temperatures.

THE ENERGIZING CHEMICALS in PARK NON-BURNING carburizers are evenly distributed throughout the granules. The compound retains its carburizing potential indefinitely and is not damaged by handling. Its weight per cubic foot is considerably less than smeared coke type materials.

THE SMALLER SIZES of PARK NON-BURNING carburizing compounds are ideal for packing small parts and a special grade prevents copper migration on copper plated parts.

*Complete data on this 20 cycle run and other tests available upon request.

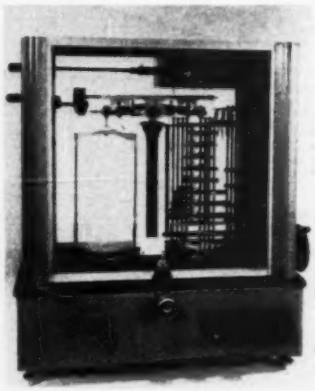
• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

Park
CHEMICAL COMPANY
8074 Military Ave., Detroit 4, Mich.

ENGINEERING DIGEST OF NEW PRODUCTS

ANALYTICAL BALANCE: A new analytical balance, the Speedigram, which permits untrained personnel to weigh objects quickly, with complete accuracy and without the use of computations or interpolation, has just been introduced by Voland & Sons, Inc.

With this new instrument, inexperienced operators have achieved weighing times of less than two minutes. The Speedigram is therefore proving to be an important factor in production laboratories for volume procedures.



This analytical balance reads directly up to 100 grams without weights. An extra 100 grams weight is supplied, however, so that the full capacity, 200 grams, of instrument is available. The sensitivity of this analytical balance is 0.05 mg. at full loads.

Numerals appearing through the plate over the dials indicate the weights which will be deposited on the pan. Deposition is automatic when the beam is released. Readings are made across the dial so that no arithmetical sums need be computed, thus eliminating a major source of error in analytical weighing.

Simplicity itself in design, the Speedigram has no complicated parts to get out of order and its working parts are in full view.

For further information circle inquiry card number 968.

SURFACE PYROMETER: The rising demand for an inexpensive yet accurate and universally adaptable method for determining surface and sub-surface temperatures in almost every conceivable industrial plant or laboratory has prompted The Pyrometer Instrument Company, Inc., to develop an all-purpose instrument to meet this requirement.

This new instrument features a large 4 in. direct reading indicator mounted in a rubber-cushioned housing, thus offering great ease in reading as well as long, durable service. Two distinct series of models offer either a rigid extension arm or a long 42 in. flexible arm suitable for use with any one or more of a selection of eight types of available thermocouples. Each series of instruments is available in four temperature ranges from 0-400° F. to 0-1200° F., and all thermocouples may be interchanged without adjustment or recalibration.

This completely self-contained, portable, compact and quick-acting instrument with the wide selection of thermocouples makes it ideally suited to almost every industrial surface and sub-surface temperature measurement problem.

For further information circle inquiry card number 969.

SPECIAL ILLUMINATOR: A special illuminator has been developed by Buhl Optical Co. for use with its S-129 pocket microscope. The microscope, having selective magnification ranging from 40 to 60 power, is widely used in industry for inspecting raw materials as well as cast, machined, and finished surfaces of all kinds.

Although the Buhl pocket microscope is designed for use with normal room lighting, some applications have required use in dark, inaccessible places. The new illuminator answers this purpose.

For further information circle inquiry card number 970.

CONTOUR AND FLAT POLISHING MACHINE: Central Machine Works announce a new Model 5—18 in. stroke hydraulic and semi-automatic polishing machine for contour and flat polishing work, such as silverware; jewelry; hand tools; decorative hardware; flat irons; blanking stock; litho plate and hub caps. The manufacturer claims a considerable savings over present methods now in use can be accomplished by the use of these machines. Also made in Model M.M. with 30 in. stroke.

For further information circle inquiry card number 971.

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

972. Abrasive Segments
Four-page bulletin ESA-138 explains how segments are used, their advantages, discusses abrasives and bonds employed. Includes grain and grade recommendations of abrasive segments for both surface grinding and machine knife grinding operations. *Simonds Abrasive Co.*

973. Abrasive Wear
Six-page bulletin, "How to Reduce Abrasive Wear with Thermalloy HC-250", describes the physical properties of the thermalloy HC-250 and lists the many uses and advantages of this exceptionally abrasive-resistant metal. *Electro Alloys Div.*

974. Alloy Steel
New 36-page brochure, "For Longer Wear, Less Repair", describes Jalloy, a new special alloy steel capable of being heat treated to excellent physical properties. *Jones & Laughlin Steel Corp.*

975. Alloys
New 40-page booklet featuring articles on company history, how to specify and order phosphor bronze, nickel silver, cupro nickel, beryllium copper and miscellaneous alloys, along with a chapter on temper and many useful tables and data on weights and tolerances. *Riverside Metal Co.*

976. Aluminum Alloys
New condensed reference chart giving the properties of most of the aluminum alloys available in the form of wrought products. *Revere Copper and Brass, Inc.*

977. Blowers
New bulletin 120-B-14 illustrates and lists operating characteristics of centrifugal blowers and exhausters. Also carries description of R-C "dual-ability", stressing advantages of both rotary positive and centrifugal units, along with list of other R-C products. *Roots-Connersville Blower Corp.*

978. Camera, High Speed
"Magnifying Time", a new folder describing high speed camera capable of 1000 to 3000 pictures per second. Particularly adaptable for close inspection in machine tool operations and also for measuring flow of liquids as in chemical mixers, coolant flow, etc. *Eastman Kodak Co.*

979. Carbonitriding Steel
New 6-page booklet, "Carbonitriding of Steel", discusses its history, advantages, theories, atmospheres, equipment, operating conditions and industrial applications of this process. *Armour Ammonia Division.*

980. Carburizing-Martempering
Article entitled "Carburizing-Martempering Procedure Streamlines Crankshaft Heat Treating" covers technique employed in combining liquid carburizing and martempering in a single heating operation. The economies effected are compared with the heat treating process replaced. *Ajax Electric Co.*

981. Cast Irons
Fully descriptive booklet is available on the many advantages of Molybdenum Cast Irons. *Molybdenum Corp. of America.*

982. Castings
New booklets entitled "Engineering Properties and Applications of Ni-Hard" and "Buyers Guide for Ni-Hard Castings" list general information on selection and performance of this unique nickel-chromium white cast iron. *International Nickel Co.*

983. Castings
New 72-page book entitled "Castings by Howard" contains information on zirconium and rare earth magnesium-alloying elements. This book also includes helpful, understandable information on the casting of aluminum, magnesium, brass, bronze and semi-steel as well as numerous tables showing mechanical properties, chemical analysis and physical characteristics of these metals. *Howard Foundry Co.*

984. Castings
Bulletin No. 7 describes how National Erie serves the metal industry by supplying medium and small castings by controlling every operation from raw metals to finished product within their one plant. *National Erie Corp.*

985. Castings, Nonferrous
New 16-page catalog describing nonferrous castings and metal pattern operations. Covering such subjects as magnesium and aluminum alloys; polishing of aluminum; examples of good castings; copper-base alloys; and other pertinent information on production. *Wellman Bronze & Aluminum Co.*

986. Combustible Recorder
New 16-page bulletin shows design improvements for the Bailey combustible recorder, with illustrations of typical applications for industrial furnaces. *Bailey Meter Co.*

987. Combustion Control
"Combustion Control for Industry", a new fact-filled free booklet now available, shows how greater savings can be realized by proper combustion in heat treating units of any size. *Cities Service Oil Co.*

988. Corrosion
Complete line of quality rust preventives, both oil and petrolatum types for interior and exterior use, described in booklet "Gulf Rust Preventives". *Gulf Oil Corp.*

989. Corrosion, Piping
New bulletin 485 on "Corrosion Service Piping" is a comprehensive treatment on stainless steel in nickel-alloy anti-corrosion and anti-contamination piping. This illustrated book discusses economics, standards, advantages of welding, extensive technical data, design tips, and complete dimensional information on stainless fittings and flanges. *Taylor Forge & Pipe Works.*

990. Die Castings
Revealing book, "How Magnesium Pays", gives case studies of the economical use of magnesium in a wide range of products. *Dow Chemical Co.*

991. Electric Heater
An almost endless variety of standard electric heating units, many entirely new, are listed in the new Chromalox catalog of industrial electric heaters. *Edwin L. Wiegand Co.*

992. Electrodes
Booklets EW-141 and EW-137, an electrode catalog and welder catalog, show complete lines of arc welding electrodes and AC and DC arc welders. *The Hobart Brothers Co.*

993. Electrodes, Low Hydrogen
Booklet 1249 gives specific information on the use of low hydrogen electrodes for welding low alloy cast steels and high tensile strength rolled steels; high carbon steels, high carbon to mild steels and free machining steels. *Arcos Corp.*

994. Finishes
New "Black Book" gives full details on black magic finishes for steel, iron, zinc, cadmium, copper and its alloys. *Mitchell-Bradford Chemical Co.*

995. Finishes
Bulletin 1400 tells how the new Hydro-Finish provides cleaner, smoother surfaces prior to coating processes; saves hours on the production line. *Pangborn Corp.*

996. Furnaces
New 4-page booklet 710 stresses the importance of efficient furnace combustion and describes practical, simple way the CO_2 analyzer measures CO_2 content of flue gases to help the air supply at an optimum level. *Charles Engelhard, Inc.*

997. Furnaces
Catalog 110 features new heat treating furnaces and atmosphere charts. *C. I. Hayes, Inc.*

998. Furnaces
New all-purpose furnace described in bulletin HD-646 may be used for carburizing, nitriding, dry cyanking, bright annealing and clean hardening. *Heat Duty Electric Co.*

999. Furnaces
For full information on uniform, low-cost operation, write for bulletin 461. It illustrates seventeen sizes and types with brief descriptions of each. *Electric Furnace Co.*

1000. Furnaces
New catalog on Heroult gantry-type electric melting furnace with patented roof-ring to assure speedy and simple bricking and elimination of skew shapes. *American Bridge Co.*

1001. Furnaces, Laboratory
New speed oven saves time and cost in laboratory drying. Leaflet describes how samples are dried twice as fast by hot, filtered air driven at high speed. *Harry W. Dietert Co.*

1002. Galvanite Handbook
A new 12-page, illustrated handbook explaining the uses, manufacture, and advantages of Galvanite, a special hot-dip, zinc-coated steel produced by this company. *Sharon Steel Corp.*

1003. Gas-Cutting Guide
Pocket-sized oxyacetylene machine gas-cutting guide has now been reprinted. By means of a handy slide-rule type of chart, tip numbers are indicated, and oxygen and acetylene pressures, speed in inches per minute, gas consumption and approximate width of kerf are all easily read down one column. Cleaning drill sizes are also indicated. *Air Reduction Sales Co.*

1004. Graphite Combustion Chambers
M-9602 describes the graphite combustion chambers and "Karbate" impervious graphite burner nozzles. Outlines operation of the complete system and points out the principal features, such as long life, absence of corrosion, minimum maintenance, ability to withstand thermal shock, simplicity and moderate installed first cost. *National Carbon Co.*

1005. Grinding and Polishing
New booklet entitled "Why Thousands of Shops Have Switched" describes advantages of backstand grinding and polishing metalite cloth belts. *Behr-Manning Corp.*

1006. Hardness Tester
New portable hardness tester with 2-in. throat capacity for greater range now available. Write for booklet with full description. *Ames Precision Machine Works.*

1007. Heat Treating
Form 7340 C, an 8-page illustrated article, contains interesting story of the conveyorized harden, quench and draw installation at American Fort Pitt Spring Division. *Sunbeam Stewart Industrial Furnace Div.*

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

1008. Heat Treating

New bulletin now available on Series T Ipsen automatic heat treating unit for lower costs and efficient operation. *Ipsen Industries, Inc.*

1009. Malleable Castings

New brochure describes the advantages of malleable iron castings and pictures the expanded facilities of this company. *Mosmas Malleable Castings Co.*

1010. Melt Welding

"Unionmelt Apparatus Catalog" contains 36 pages of latest information on Unionmelt equipment and supplies for submerged melt welding. Also includes a section on rebuilding of worn surfaces. *Linde Air Products Co.*

1011. Metal Coatings

Explanations of high-vacuum evaporation of metals and other solids set forth in detail in new 12-page booklet, "Vaporized Metal-Coatings by High Vacuum". *Distillation Products, Inc.*

1012. Metal Finishing

Technical bulletin entitled "Modern Metal Finishing" describes timely and useful developments in the treatment of metals, such as electroplating, descaling, metal cleaning, and heat treating. *E. I. duPont de Nemours & Co.*

1013. Metal Forming

Four-page leaflet describes Marform, a unique new process of precision metal forming for alloy steel, copper, brass and other metals. *Glenn L. Martin Co.*

1014. Microhardness Tester

Descriptive leaflet on MH microhardness indenter, a new instrument for measuring hardness of microconstituents, fine wire, metallic foils, electrodeposited coatings, etc. Adaptable to table microscopes, simple to operate and low in cost. *Erb & Gray.*

1015. Microscopes

Illustrated data sheets describing S-129 pocket microscope (40 to 60 power), the S-152 Handiscope (20 power), and the S-42 Magniprox desk magnifier. *Buhl Optical Co.*

1016. Nonferrous Cleaners

New bulletin describing the use of alkaline cleaner for degreasing of nonferrous metals, including copper, brass, tin alloys and lead alloys. *Enthone, Inc.*

1017. Oils, Quenching

Interesting booklet describes many advantages of various quenching oils developed for uniform hardness in heat treating, higher viscosity where oil remains abnormally hot, and longer service life. *Sun Oil Co.*

1018. Optical Glass

New bulletin E-30 discusses the physical and chemical properties of optical glass. This book also contains general data on optical glass products. *Bausch & Lomb Optical Co.*

1019. Pack-Hardening and Isolating Pastes

An attractive bulletin describes Carburit, the perfect solution to selective hardening problems, requiring no furnace. Also describes the new easy-to-use isolating paste, Isopac, that keeps desired sections soft when hardening in box, salt bath or other methods. *Denks Chemical Labs.*

1020. Polishing

New booklet, "Polishing Cloth and Abrasives", furnishes first-hand description and classification of some of the most used but least described accessories in modern sample preparation. *Buehler, Ltd.*

1021. Potentiometers

Dynalog instruments for control of temperature, humidity, pressure, flow, etc. Details in bulletin 427. *Foxboro Co.*

1022. "Precisionomics"

A new house organ issued every other month will feature articles directed to the scientist and laboratory worker engaged in the petroleum and metallurgical fields. *Precision Scientific Co.*

1023. Presses

Valuable reference catalog 949 contains 60 pages of important information on pressure vessels, styles and types and other handbook material. Sent upon request on company letterhead. *Hydraulic Pressing & Forging Co.*

1024. Presses

16-page bulletin contains complete catalog information and specifications on the line of heavy-duty autofed presses. *Danly Machine Specialties.*

1025. Pressure Vessel Accessories

Valuable reference catalog 9-49 contains 60 pages of important information on pressure vessels, styles and types and other handbook material. Sent upon request on company letterhead. *Lenape Hydraulic Pressing & Forging Co.*

1026. Process Equipment

New 36-page book lists the company's products and activities in process engineering, from complete plants to individual machines. Catalog includes grinding, mixing, classifying, processing, heat exchange equipment, hydrogenating, gas absorbing, and many other units. *Patterson Foundry & Machine Co.*

1027. Products and Processes

New booklet entitled "Products and Processes" outlines the principal activities of the major corporation groups, including: alloys and metals; chemicals; electrodes, carbons and batteries; and industrial gases and carbides. *Union Carbide & Carbon Corp.*

1028. Radiant-Tube Heating

Eight-page illustrated bulletin on radiant-tube heating of controlled atmosphere heat treating furnaces discusses the development and design of radiant tubes and the advantages provided by this heating method. *Holcroft & Co.*

1029. Recorders

Condensed catalog Z6500 gives full description of Capacilog Recorder and other instruments for application in all types of laboratory classification. *Wheelco Instruments Co.*

1030. Refractories

New catalog entitled "Leco Zircon Refractory Ware" lists and describes zircon-base refractory products offered. *Laboratory Equipment Co.*

1031. Refractory Bonding Mortar

New booklet 322F describes Q-Chrome, the flame and slag resistant, neutral-base refractory bonding mortar. *Quigley Co.*

1032. Refractory Concrete

Detailed information furnished on methods of using refractory concrete in annealing furnaces. *Lumnite Div., Universal Atlas Cement Co.*

1033. Rotary Files and Burs

Brochure illustrating complete line of rotary files and burs for removing scales from castings; cutting in hard-to-get-at places; die-sinking; pattern making, etc. Also includes sizes and prices. *Martindale Electric Co.*

1034. Rust Preventives

Eight-page bulletin entitled "New All-Star Line-Up of Rust Preventives" describes and lists the many uses for each of the 11 Rust Veto products developed by this firm. *E. F. Houghton & Co.*

1035. Solders

Bulletin 43 gives full information on low-temperature silver solders. Samples sent on request. *American Platinum Works.*

1036. Steel, Zinc-Coated

Fully illustrated booklet, "Armco Zincgrip-Paintgrip", tells how this special-purpose steel sheet furnishes high corrosion resistance as well as stretch quality for sharp bends or flat parts of fabricated products. *Armco Steel Corp.*

1037. Steels, Alloy

New 24-page booklet, "How to Specify and Buy Alloy Steel with Confidence", emphasizes the importance of careful selection, positive knowledge of properties and accurate heat treatment in purchasing alloy steels. *Jos. T. Ryerson & Son, Inc.*

1038. Steels, Alloy

Critical points of 85 standard carbon and alloy steels, legibly printed on a lasting celluloid pocket card 2¾ x 4¾. Includes Ac1, Ac3, Ar1, Ar3 and Ms temperatures for A.I.S.I. and S.A.E. types in current use. *Republic Steel Corp.*

1039. Strain Gages

Twelve-page catalog on Baldwin SR-4 bonded resistance wire strain gages is illustrated by line drawings distinguishing eleven types of gages and listing 102 standard models. *Baldwin Locomotive Works.*

1040. Testing

Bulletin 37 describes dependable qualities of Electromatic testing machines equipped with electronic high-magnification recorder. *Tinius Olsen Testing Machine Co.*

1041. Testing

Production-line testing of motors, transformers and generators is speeded up by use of new G-E winding-insulation tester. Described in bulletin GEC-521. *General Electric Co.*

1042. Tool Steels

Write for new 176-page handbook, "The Tool Steels of Allegheny Ludlum", covering all the leading types and grades of tool steels. *Allegheny Ludlum Steel Corp.*

1043. Twist Drills

New 48-page pocket-size catalog on a recently introduced line of high speed twist drills and reamers covers all standard sizes and types, as well as a wide range of other special-purpose drills and reamers. *Chas. H. Besly & Co.*

1044. Vacuum Metallurgy

Bulletin entitled "National Research Corp. and Vacuum Metallurgy" gives brief resume of the vacuum metallurgical operations and background of this company and of the research and development facilities and services available to the metallurgist. *National Research Corp.*

1045. Vacuum Pumps

Bulletin V-45 describes complete range of high-vacuum pumps for insuring positive lubrication and long equipment life. *Kinney Mfg. Co.*

1046. Welding Bronze

How to save material by bronze welding, an ideal combination for repair welding, building up worn surfaces and production welding, described in new 17th edition of B-13. *American Brass Co.*

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METAL PROGRESS

7301 Euclid Avenue, Cleveland 3, Ohio

December, 1949

956	976	996	1016	1036
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Resistance Alloys (Ni-Cr Type)*

IT HAS BEEN KNOWN for a number of years that the addition of small quantities of an alkaline earth or a rare earth metal to chromium-nickel or iron-chromium-nickel alloys for resistance heater elements markedly increases their oxidation resistance, as determined in intermittent oxidation tests similar to the A.S.T.M. specification B76-39. The mechanism whereby such small additions exert so profound an effect is as yet unexplained. It has been observed that those elements are effective whose atomic volumes are greater than that of NiO and it has been suggested that these elements occupy "holes" in the Cr_2O_3 layer and thus prevent the diffusion of nickel through the protective scale. It was Lore Horn's purpose, in the paper now under review, to elucidate this problem.

The effects of various alloy additions (Be, Ca, Al, Si, Ti, Zr, Ce, Th, Cr, Mo, W, Mn, Cu and Au) on the oxidation of nickel were investigated by measuring the continuous oxidation of a number of binary compositions of these metals at temperatures of 700 to 900° C. (1300 to 1650° F.). The samples were suspended within a furnace and their weight gains (in air) continuously measured, at temperature, by a microbalance.

In all oxidation tests, the curves of weight gain versus time conformed to the parabolic law — that is, the square of weight-increase per unit of area was proportional to time; the proportionality constant k (scaling constant) was then chosen as an index of oxidation rate. In a space diagram in which the scaling constant was plotted versus the alloy content and temperature of oxidation, three general types of diagrams were differentiated. The normal type (for example, that of the nickel-aluminum series) at each temperature showed at first a rapid and later a diminishing rate of increase of the scaling constant with increasing alloy content. The second type (characterized by the Ni-Be and Ni-Si series)

(Continued on p. 868)

*Abstract of "Über den Einfluss von Zusätzen auf die Oxydation von Nickel und Chrom-Nickel-Legierungen" (The Effect of Additions on the Oxidation of Nickel and Chromium-Nickel Alloys), by Lore Horn, *Zeitschrift für Metallkunde*, Vol. 40, Feb. 1949, p. 73-76.

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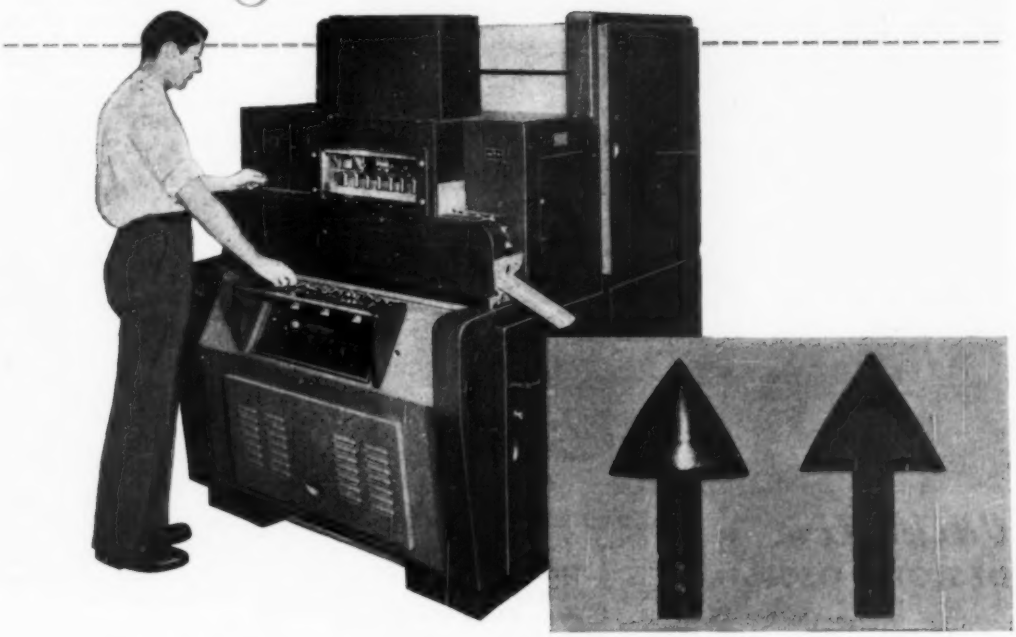
Westinghouse



The Proof of the Profit... is in the Heating!

Don't take our word for it! Look at the record piled up by Westinghouse RF Heating Equipment installed at Charles A. Richardson, Inc., West Mansfield, Massachusetts. The Richardson Company manufactures several million shuttle tips each year. Certain areas of these tips require hardening and other areas must be left soft.

Richardson previously heat-treated with oil-fired pot furnaces. With this process rejects were high, due to lack of control. They turned to Westinghouse and RF Heating. NOW rejects are negligible . . . AND . . . PROFITS are UP.

Proof: PRODUCTION TRIPLED! The old method of hardening produced only 1,000 tips per man-hour. RF Heating yields 3,000 tips per man-hour . . . with unskilled labor!

Proof: COSTS SLASHED. Figures speak for themselves . . . actual cost checks revealed that production costs per tip were down substantially.

Proof: BETTER PRODUCT! No chance for errors . . . entire operation after loading is fully automatic. Westinghouse RF Heating accomplished *exactly* the hardening desired in the areas it was required, as shown in the photograph above.

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RF HEATING

Resistance Alloys

(Continued from p. 866)

showed first a slight increase in scaling constant and then a sharp decrease. The third type of diagram (peculiar to the nickel-chromium series) was an exaggeration of the second type, and exhibited a very marked rise in scaling constant up to 6% chromium and then an equally sharp drop. In each type of diagram the variation in k with temperature at a fixed composition was exponential.

It was particularly noted that cerium, calcium and thorium, small additions of which cause a marked improvement in the oxidation resistance of chromium-nickel alloys in intermittent tests, cause, on the other hand, a decrease in continuous tests of their binary alloys with nickel. It was, in fact, generally noted that small additions of all the elements to nickel caused an increase in the scaling constant (a decrease in oxidation resistance) up to compositions at which the scale was still principally NiO. Decrease in the scaling constant with further alloy additions, as noted in the second and third types of space diagrams, was attended by changes in the oxide composition.

The increase of the scaling constant per atomic per cent of added alloy was chosen as an index for evaluating the experiments. It was found that this index increased more or less proportionally to the difference in atomic radii of nickel and the added element. The life of chromium-nickel base alloys, as measured in intermittent oxidation tests, also varies with the atomic radius of added elements, in this case increasing with atomic radius. Horn interpreted these experimental results by postulating an increase in the mobility of nickel atoms in binary alloys due to the addition of the second element, the mobility increasing with lattice distortion or with an increase in the difference between the atomic radii of nickel and the added element. In nickel-chromium base alloys the function of the third element was interpreted as causing an increase in the mobility of chromium atoms, thus favoring the formation of protective Cr_2O_3 scales. However, the conclusions would be more acceptable if some experimental data had been presented to confirm the postulated mechanism of the effect of added elements on the diffusion rates.

B. LUSTMAN

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TYPE OR-194 POT FURNACE

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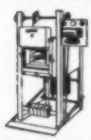

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with Hoskins CHROMEL*—equipped electric furnaces

Good, dependable performance . . . uniform distribution of heat . . . efficient, low-cost operation and maintenance. These are the basic characteristics built into every Hoskins electric furnace. Look at 'em. Their sturdy, rugged construction bespeaks a long and useful life. Check their insulation. You'll find it where it's needed . . . to hold heat in, keep power costs down, assure more comfortable working conditions. Then consider their heating elements. *Durable CHROMEL heating elements!* Designed to give you maximum heating efficiency, long-life trouble-free service. Designed for quick and easy replacement when at last required. Designed from end to end to *fit* the furnace that *fits* your heat treating operations! Our Catalog-59R describes the complete line of Hoskins electric furnaces . . . want a copy?

*CHROMEL . . . the original nickel-chrome alloy that first made electrical heating practical.

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Heating Element Alloys ★ Heat Resistant Alloys ★ Thermocouple Alloys ★ Spark Plug Electrode Wire ★ Special Alloys of Nickel ★ Electric Heat Treating and Laboratory Furnaces

Vacuum Distillation of Metals*

THE SMELTING of metallic ores always means a positive reduction in the metal resources of the world. Unlike the forests, these ore deposits are not replaced by nature at a measurable rate. Having been produced in metallic form, the refined metals are frequently, if not generally, alloyed with others for final use, and so pass into effective circulation. Their life cycle is completed as the various materials made from these alloys become worn out and enter the scrap metal field. In addition to these there is a large amount of machine cuttings, turnings and grindings that constitute a recirculating load in our industrial system.

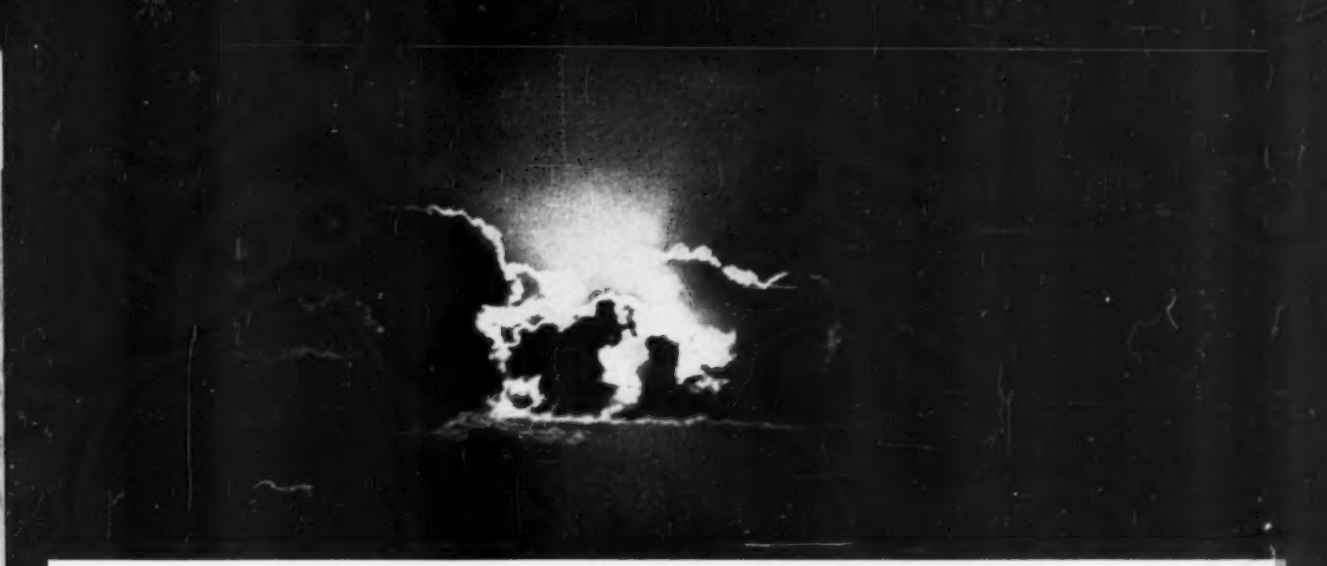
Unfortunately much of this used material is not well segregated as to composition. This results in ever-increasing quantities of unusable material, some of which is treated by the smelters to recover some of the elements of its composition, but leaving much that is a total loss in slag or smoke. This being the situation, all users of metal (and this today means almost everyone) have an interest in any new process that has for its object the separation and recovery of two or more alloy components.

Messrs. Spendlove and St. Clair of the U. S. Bureau of Mines have studied the separation of zinc from an 80-20 Zn-Al alloy, using the method of distillation *in vacuo* (pressure of 0.5 mm. of mercury or less). In certain respects it might be likened to the separation of one liquid from a mixture, as is common in chemical manufacture and petroleum refining. The authors' prime aim was to study the equipment and techniques involved in the distillation process.

It was known, for example, that an aluminum-zinc alloy could not be purified much below 10% zinc by vaporizing the zinc at atmospheric pressures, because the temperatures for further distillation become so high some aluminum is carried off too. At the low pressure investigated, however, zinc started to volatilize from the 80-20 alloy

(Continued on p. 876)

*Comments on "Low Pressure Distillation of Zinc From Al-Zn Alloy", by Max J. Spendlove and Hillary W. St. Clair, *Journal of Metals*, Sept. 1949, p. 553. A paper for presentation at the Feb. 1950 meeting of the American Institute of Mining and Metallurgical Engineers.



THE PICTURE. What does your imagination picture in the clouds? Do you see a poodle begging an old witch for a pork-chop, a lamb gamboling to the right, and what else? If you've "outgrown" your imagination, forget it.

Imagination!

Imagination, the stuff of dreams, knows no boundary of space, or form, or budget. She may dance capriciously with elves in the moonlight, cut paper dolls from storm clouds, — even look down upon the stars.

But, make no mistake, she abounds in substance with eager power to lift you from your rut! She is the opportunity that knocks from *within*. If you have the *spirit* to transcend mediocrity, you will hear and follow. She is sprightly, incandescent, elusive, at times fickle. She will pause to aid him who hopes and tries *and tries* to untie the *smallest* knot or solve the *toughest* riddle. She will project your thought over any route you plan to travel and point out, *through your pencil*, all of the obstacles which lay-in-wait, and the short-cuts to your goal.

Imagination has Patience; she will linger while you break with Precedent, smile while you dally with Habit, then guide you to Understanding. But you, too, must have Patience, and the wisdom not to form conclusions in ignorance, or base your belief on the "thinking" of others.

For her own amusement she has given names to a thousand Gods, spun the priestly potter to beget the clods and stones to build a million temples (complete with turnstiles). She has paved the streets of Heaven with Gold and of Hollywood with mink and long ranges of firm, pink mountains. She had a hand in Esquire's Calendar, and should shortly produce needed improvements on "Dynaflow and Hydramatic". For the first time in a generation she is striving to raise the sights at Pullman-Standard and bring a bold new vista of modernized rail transport into form.

Imagination, in the automotive field, wears Seven League Boots. Nowhere has she fired the minds of men as in motors and aviation where the only certainty is *Change* and all motion adds to Progress! When we stuck our necks out to form the first enterprise wholly devoted to the Engineering and Casting of Heat and Corrosion Resistant Alloys, we cast our lot with the men of automotives. It has been a privilege to serve them, and to share their restless dissatisfaction with things in being as they plan and build with imaginative vision and inspired vigor.

Automotive "Precedents" are born "notched" to facilitate breaking. In this respect they differ from the "Cast-iron" Precedents of the foundry industry to which background the casting of complex alloys was fused by happenstance and/or necessity. We grew up with our feet mired in the technical stagnation of the foundry. Our minds expanded with the exploration and conquest of uncharted metallurgical fields in the metallurgy of complex alloys. Meanwhile we shared the Imagination and the "Loyalty to the Vision of Work well done" of the automotive, and later the Process, Industries.

From such breadth of activity and conflict of technological concept, over a quarter century, we developed an approach to the evaluation of our own ignorance. Surely, in our diversity of alloys, in the unprecedented degree of metallurgy, of engineering design and application we applied, nation-wide, to thousands of "Severe Service" installations. We followed no published art, no path trod by foundrymen.

When we projected a comprehensive program of Research and Development for (a) more accurate control of as-cast structures, (b) improved dimensional control of castings, and (c) the elimination of sands, and related defects, from castings, we sought to eliminate all questionable data. This meant discounting or completely eliminating all data on conventional foundry practice in steel and alloys. So we started from "Scratch".

Enter Imagination. Let us imagine that there were no foundries, that (a) we were given the problem of melting and casting metals to highest "practical" specifications, economically, in commercial quantities, (b) that we had access to all existent and historical art and technology on casting processes, (c) that we could enlist all known arts and technology in any desired combination. (d) that we were free to project and evolve new techniques and build the tools to implement them.

For two and a half years we have been living that "Dream", through Navy sponsorship of a Casting Research and Development Project. Imagination, implemented by stout hearts, hard work and sharp tools, has led us across frontiers.

Working "from the rim toward the hub", through a complexity of dynamic variables, we have precipitated the basic concepts, established the fundamental controls, by which the casting of metals can be immeasurably advanced. The conclusions appear, as do all reductions to logic, *simple and obvious*. In thus confirming our contention that "Good practice is sound theory reduced to function", we have found satisfaction. Imagination has *delivered* the goods. We will keep her on the payroll, *forever insubordinate!*

Through the Glorious Imaginative conception of CHRISTMAS, we hope that you have more fully lived and enjoyed the departing year. May good health, the love of your family and the respect of your fellowman abide with you in the New Year. Given these, the Gift of Imagination and the *courage to live creatively*, you will make your mark in the years to come.

On this, my 50th Christmas, I am humble as I contemplate how little has been accomplished and how much remains to be done; but, believe me, our zest for the quest of knowledge has but *sharpened with the years!*

An "Editorial" by the President of General Alloys Company, "Oldest and Largest Exclusive Manufacturers of Heat and Corrosion Resistant Castings"—Boston, Mass.

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

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SECOND ...new G-E welding electrode comparator

Here's all the electrode comparison information heretofore available only on large, unwieldy charts—condensed into a handy, pocket-sized slide-rule. Naturally, it includes all G-E electrodes—mild-steel, special alloys, low-hydrogen, stainless-steel, hard-surfacing, etc.; and it covers the standard electrodes of all principal manufacturers—all suitably keyed to AWS classification numbers. And it's easy to use . . . just set the rule, and read off the comparison data directly. You'll find it the handiest means of comparing electrodes you've ever come across.

Clip the coupon for your free copy of the new G-E welding electrode "Comparator."

And here's a special bonus! Mail the coupon today, and we'll also send you a copy of the brand new edition of the pocket-sized G-E Arc-welding Electrode Catalog!

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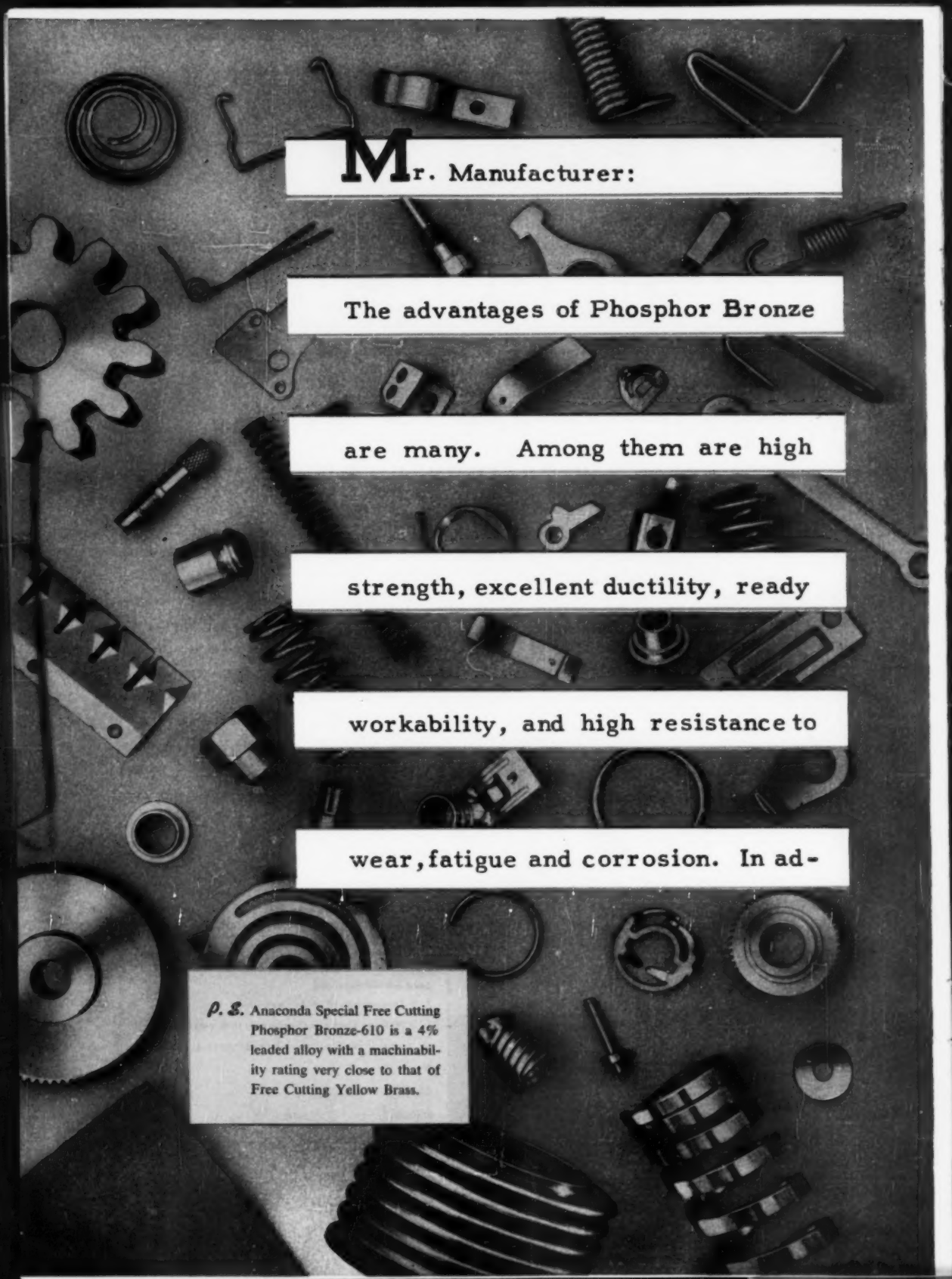
Mr. Manufacturer:
The advantages of Phosphor Bronze
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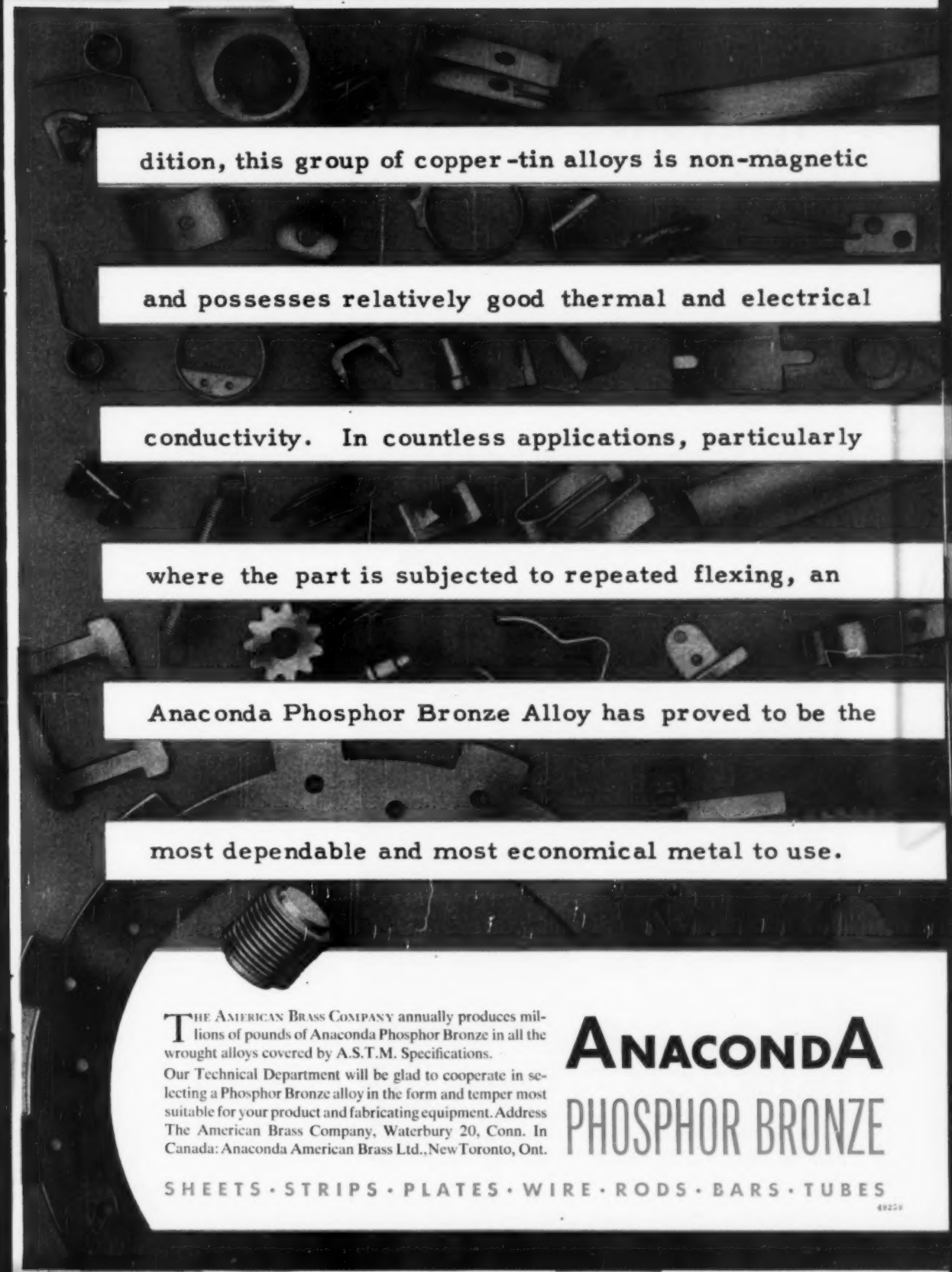
strength, excellent ductility, ready
workability, and high resistance to
wear, fatigue and corrosion. In ad-
P. S. Anaconda Special Free Cutting Phosphor Bronze-610 is a 4% leaded alloy with a machinability rating very close to that of Free Cutting Yellow Brass.


dition, this group of copper-tin alloys is non-magnetic
and possesses relatively good thermal and electrical
conductivity. In countless applications, particularly
where the part is subjected to repeated flexing, an
Anaconda Phosphor Bronze Alloy has proved to be the
most dependable and most economical metal to use.
THE AMERICAN BRASS COMPANY annually produces millions of pounds of Anaconda Phosphor Bronze in all the wrought alloys covered by A.S.T.M. Specifications.
Our Technical Department will be glad to cooperate in selecting a Phosphor Bronze alloy in the form and temper most suitable for your product and fabricating equipment. Address The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.
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Vacuum Distillation of Metals

(Continued from p. 870)

at about 525° C. (975° F.);* as the molten alloy progressively lost zinc the temperature for further extraction rose until at the end of the tests (900° C. or 1650° F.) the molten residue contained about 0.2% Zn. Within the upper range of temperature the molten metal tends to spatter and tiny shot of aluminum lodge in the condensed zinc, reducing its purity. However, if the operation is stopped at about 600° C. the condensed zinc contains no more than 0.01% Al, but the residual aluminum alloy contains about 4% Zn. This should be an acceptable metal as the basis for many of the strong aluminum alloys in use today. (Other impurities were 0.02% Fe and a trace of cadmium from the zinc.)

The equipment used in the tests were a high-frequency induction furnace capable of holding 150 lb. of molten alloy. Immediately above its top was sealed a water-cooled condenser, the two being separated by heat baffles. The authors point out one important advantage of vacuum distillation — that the vaporization occurs at the very surface of the melt, whereas during boiling at normal pressures, vapor is generated within the melt and its rise and escape is associated with considerable turbulence and spattering. It might also be added that another advantage is that the distillate condenses into a coherent mass rather than as an oxidized snow ("blue power", in the case of zinc).

Tables are presented showing the heat balance for the distillation furnace and for the condenser.

As the authors state in their introduction, although the experiments were confined in this instance to the separation of zinc from aluminum, the significance of the results is by no means confined to these two metals. When we bear in mind that the distillation of zinc from lead is already being practiced, we are justified in concluding that the authors of this paper have erected another sign post on the road to metal recovery and metal saving. H. J. ROAST

*At atmospheric pressure the melting point of pure zinc is 419° C. or 787° F.; of pure aluminum is 660° C. or 1220° F. At atmospheric pressure the boiling point of zinc is 906° C. or 1663° F.; of aluminum is 2060° C. or 3740° F.

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Illustration above shows rings entering furnace, prepared on fixtures.

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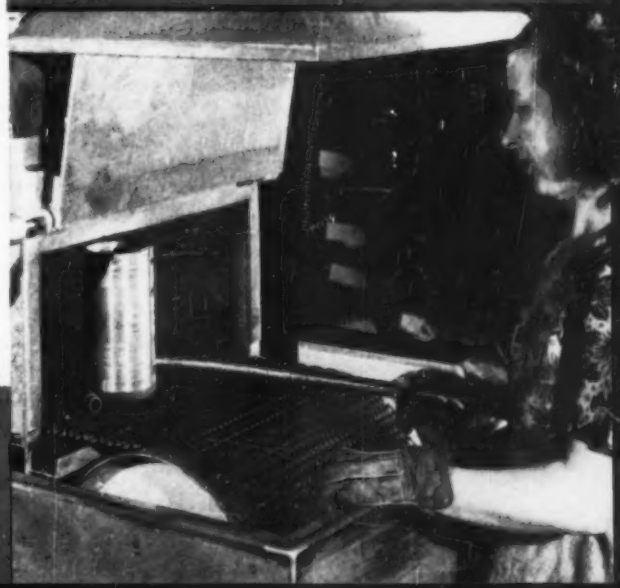
Illustration below shows unloading of fixtures with rings heat formed and possessing desired physicals to meet exact requirements.



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Bessemer Process*

THE PRESENT STATE of development of the bessemer process is the subject of a comprehensive survey by the Ad Hoc Bessemer Subcommittee of the British Iron and Steel Research Association. The report is presented under three major headings: *(a)* British Bessemer Practice, *(b)* Foreign Bessemer Practice, and *(c)* Future Bessemer Practice. Appendices include descriptions of the equipment and operations of the various British bessemer plants, a list of the bessemer plants in all major steelmaking countries except the U.S.S.R., and a bibliography of recent literature on converter processes.

The two basic bessemer plants operating in Great Britain — one at Corby, the other at Ebbw Vale — were constructed within the last 15 years and are essentially similar in general layout and operation. All of the vessels are of 25-ton capacity. The operations of Stewarts and Lloyds, Ltd., at Corby are particularly interesting; the blast furnace iron entering the mixers averages 2.0% phosphorus and 0.100% sulphur, the latter element ranging from 0.040 to 0.300% in individual casts. Soda ash treatment is employed to desulphurize the iron, first at the blast furnace and again between mixer and converter, so that the sulphur content is decreased to between 0.05 and 0.06%. The addition of lime to the converter in basic operation further reduces the sulphur so that little difficulty is experienced in making steel of 0.040% maximum sulphur. The Ebbw Vale plant of Thomas and Baldwins, Ltd., operates with iron of 0.04 to 0.08% sulphur, soda ash treatment being employed only between mixer and converter. The finished steel, analyzing 0.040% maximum sulphur and phosphorus, is rolled to slabs for flat rolled products.

Manganese is added to the steel either as red-hot ferromanganese or as liquid from a 2-ton melting furnace; these practices were at one time used in the United States but were abandoned with the introduction of large converters and high production levels.

Evidently the metallurgical effects of nitrogen in steel are well understood in England; control of

(Continued on p. 880)

*A review of "Report on the Bessemer Process", British Iron and Steel Institute. Special Report No. 42, May 1949, 80 p.

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Bessemer Process

(Starts on p. 878)

this element in converter operation has been investigated in detail. Both basic converter plants produce steel of low nitrogen content (0.010% or less) by expedients such as shallow bath operation, ore additions and control of temperature. Additions of scrap to the converter are nominal, ranging from 4 to 7% of the total weight. Blowing operations are controlled by visual inspection of the flame and examination of metal samples taken from the converter.

The total production of basic bessemer steel in Great Britain is currently 780,000 tons annually. Although the Corby plant has five converter stands and three 1000-ton mixers, only one vessel is blown at a time and a similar situation prevails at Ebbw Vale, where only one vessel operates at a time although there are two large mixers and three converter stands. To the American bessemer operator who normally handles a much greater tonnage of blown metal with less holding capacity for blast furnace iron and with fewer vessels, these rates of operation seem modest indeed. Presumably there are production limitations other than those existing in the steelworks proper. The relatively shorter life of the vessel lining in basic operation and the large quantities of lime that must be added to the converter place burdens on the equipment that are not encountered in acid practice in the United States.

There is only one large-scale acid bessemer plant in England — that of the Workington Iron and Steel Co., Ltd. — consisting of two 25-ton vessels installed in 1934 to replace an obsolete plant. The operations are fairly typical although the silicon content of the iron, 2.00 to 2.50%, is much higher than in American practice. Temperature is controlled by additions of scrap, averaging 15%. It is interesting to note that steels containing up to 1% chromium, and austenitic manganese steels (12 to 14% Mn), have been produced in this plant. Control of the process is left to the blower, although both spectroscope and photocell have been used experimentally to determine the end of the blow.

Multiplexing processes are discussed at length in the report. The acid Bessemer – basic openhearth operation is quite familiar to Amer-

(Continued on p. 882)

Bulletin on SUPER REFRACTORIES

by CARBORUNDUM
TRADE MARK

NO. 6 DECEMBER, 1949

How Super Refractories Reduce Operating Costs

Where the reduction of over-all operating costs or improved performance is a major consideration, installation of super refractories offers many economic advantages. Often, the original cost of the installation is more than repaid by increased service life alone. Further economies are obtained in freedom from frequent shutdowns—less maintenance and lowered replacement costs. Such benefits result in cases where only a few brick are used to eliminate a costly trouble spot as well as in complete installations where the durability of super refractories effects considerable savings.

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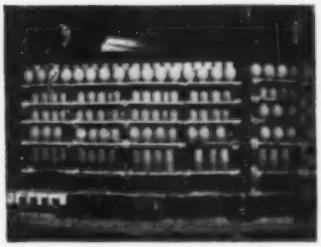
Heat Conductivity at 2200°F. in BTU/hr. sq. ft. and °F. /in. of thickness	109 BTU	16 BTU	9 BTU	24 BTU	12 BTU	7 BTU
REFRACTORINESS PCE CONE	37-40	38-39	37-38	37-39	39-40	38-39
SPALLING RESISTANCE	High	High	High	Good	Good	Good
ABRASION RESISTANCE	High	Medium	Medium	High	Medium	Low
THERMAL EXPANSION (25°—1400° C.)	.0000044	.0000059	.0000069	.0000074	.0000086	.0000086
MODULUS OF RUPTURE @ 2460° F. PSI	800-3125	100-250	175-475	100-1050	100-225	50-100
WEIGHT 9 IN. STRAIGHT	9.25 lbs.	9 lbs.	8 lbs.	10.1 lbs.	7.25 lbs.	4.8 lbs.



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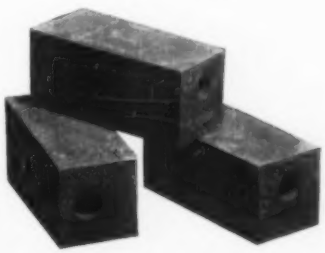

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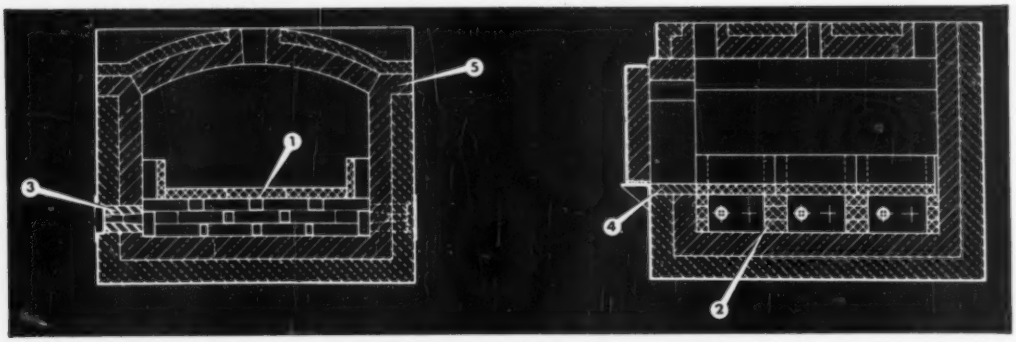

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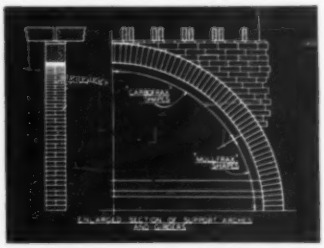

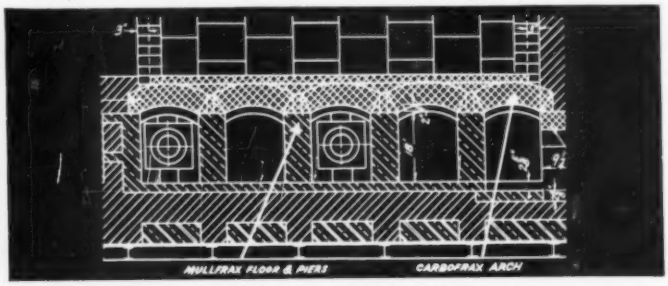

Enameling Furnace Substructure Provides Longer Continuous Service

In this typical porcelain enameling furnace substructure, CARBOFRAX arches offer the advantages of high heat transfer, long life and resistance to elevated temperatures... provide adequate and uniform support. The combustion chamber floor and piers are built of MULLFRAX brick for their lasting high load carrying strength at elevated temperatures, chemical stability and resistance to cracking. The CARBOFRAX muffle, with its high thermal conductivity, assures uniform working chamber temperatures, increased output and minimum costs. The net result is realized in overall improved furnace efficiency and economy.

A complete file of informative literature covering super refractories is available through The Carborundum Company. There are facts and figures on installations in specific fields. To obtain copies of reports, booklets and catalogs of particular interest is a simple matter. Merely select from the list printed here. Copies will be sent you at once. No obligation, of course.

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Bessemer Process

(Starts on p. 878)

ican metallurgists. In Germany duplexing usually has combined basic converter operation with basic openhearth refining, a technique that relieves the openhearth furnace of most of the burden of dephosphorizing and permits efficient operation with low slag volume and relatively high residual manganese. Bessemer-electric duplexing has been conducted successfully both with acid and basic converting as the initial step in the process; this method of operation has been tried in all of the important steelmaking countries, but does not account for any large tonnage, probably because of operating rather than metallurgical limitations.

The discussion of foreign converter practice is devoted primarily to German and American operations. The brief note on the Swedish bessemer process is largely of academic interest because of the very limited tonnage and unique metallurgical situation existing in their plants. The iron blown is high in manganese, in one instance 2.5 to 3.5%, and frequently the carbon is caught coming down. The maximum vessel size in Swedish plants is 12 tons and operations are conducted on a comparatively slow basis.

The bessemer converter accounts for a high proportion of the total steel ingot production in Germany; at the beginning of the second World War approximately 40% of German steel output was the product of basic (Thomas) converters. The position of the process was determined, not on the basis of normal influence of customers' metallurgical requirements, availability of melting scrap or production costs, but rather by the requirements of the German industrial economy. The demands for coke oven gas and other coke coproducts, as well as for electric power, resulted in large coke production and extensive blast furnace capacity. These factors, along with the need for phosphoric fertilizers by German agriculture, contributed to the important position of the basic converter in the integrated steel plants. Of interest is the large size of the converters in a number of works, several concerns operating vessels of 30 to 60-ton capacity.

During the war it became imperative as a matter of national

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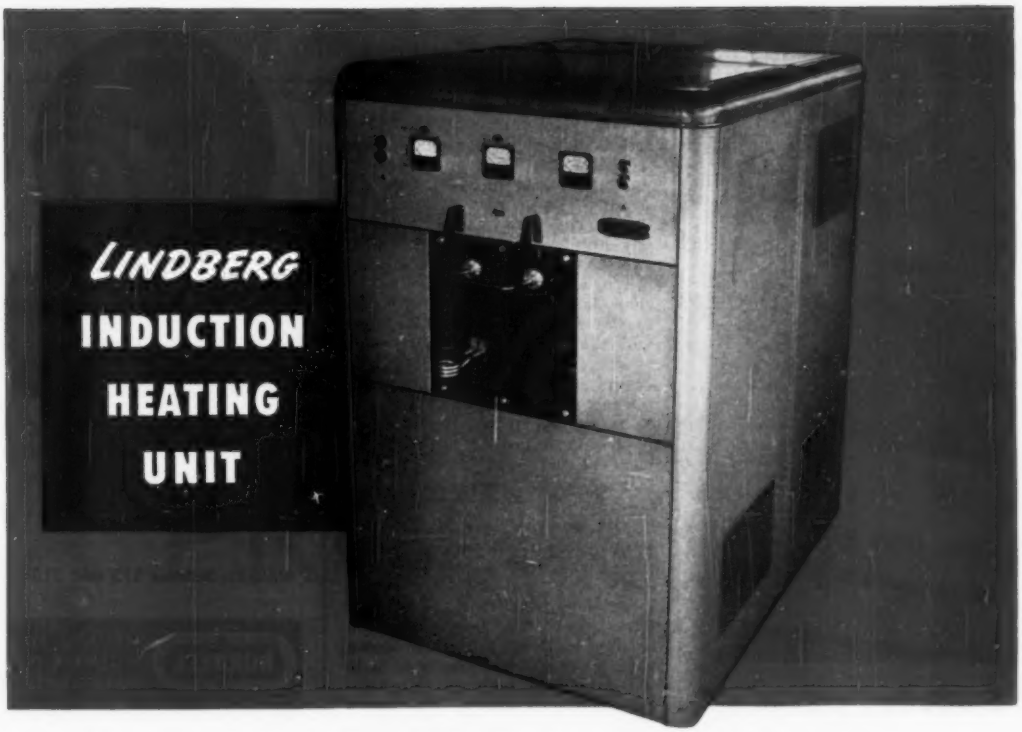
Bessemer Process

(Starts on p. 878)

policy to utilize Thomas steel for many products that had normally been produced in openhearth quality. Since low nitrogen content frequently was required in these applications, the factors determining the nitrogen content of basic bessemer steel were investigated intensively by German metallurgists. Methods employed for control included the addition of ore, shallow bath blowing, and side-blowing. At the Reichswerke in Watenstedt a double blowing technique was developed in which only 25 to 30 tons of pig iron was charged initially in a 50-ton converter and blown with the entire lime charge at normal pressure until the phosphorus was reduced from 1.75 to 0.1%. The remaining 20 to 25 tons of hot metal was then added and the blow completed. Claims made for this scheme include shorter total blowing time, reduced spitting from the converter, higher ferric yield, and lower phosphorus, nitrogen and sulphur contents. Side-blowing in a specially altered 30-ton vessel apparently was the most consistently successful technique, the bulk of the product finishing in the range 0.006 to 0.008% nitrogen. In general, the large German converter installations are designed to achieve high production levels and to permit duplexing as well as ingot production. Oxygen enrichment of the blast has been employed experimentally with some success, to reduce blowing time and to permit increased scrap consumption. During the war, converter processes were developed for unusual purposes, such as the recovery of vanadium-rich slag. These operations were dictated by necessity rather than economics, and were accompanied by significant metallurgical and operating problems.

The basic converter is employed extensively in the Minette basin — Luxemburg, Belgium and France. However, the information furnished is admittedly incomplete. The blast furnace iron in this region is substantially lower in manganese and sulphur than the usual Ruhr-district Thomas iron. Economic factors apparently are quite favorable in this region, the opinion being expressed that the cost of Thomas steel in this area is unlikely to be bettered in any other region in the world.

(Continued on p. 886)



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Bessemer Process

(Starts on p. 878)

The survey of American practice is drawn from the published technical literature and need be mentioned only briefly in this abstract. The subcommittee reports that it has been unable to obtain any first-hand accounts of American bessemer practice since 1932; hence, no mention is made of recent plants, such as those of Weirton Steel and Great Lakes Steel, which supply blown metal to open-hearth furnaces, or of the new Lorain plant of National Tube Co. for ingot production.

Developments deemed to merit further consideration are: enrichment of the blast with oxygen, large-scale side-blowing, and double blowing.

Oxygen enrichment of the blast would permit the use of lower-silicon iron and the charging of more scrap, and should result in lower nitrogen content in the steel. Experiments have been conducted in England with small side-blown converters and the results to date are promising both as to operations and steel quality. The possibilities of large-scale side-blowing are mentioned briefly, the suggestion being made that oxygen enrichment might lead to fuller development of this technique in both foundry and steelworks. Double blowing, as a means for producing low-nitrogen steel, appears to be of questionable value in acid converter plants operating at high production level, although in a basic plant where the number of vessels and capacity of cranes is adequate to the task there may be definite advantages in the control of phosphorus and nitrogen as well as in higher converter yield.

Several appended notes on foundry plants operating side-blown converters from cupola iron furnish interesting information concerning British practice in the production of bessemer steel castings. The metallurgy and operation of small side-blown converters has been the subject of detailed study by a subcommittee of the British Iron and Steel Research Association, and surprisingly numerous data are cited for various foundry operations.

Concluding the report is a bibliography of recent articles on the bessemer process, listing important papers from both American and foreign literature.

SIMON FEIGENBAUM

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(a) Abstract; (b) Biography; (c) Correspondence; (cp) Critical Points; (d) Data Sheet; (r) Review.

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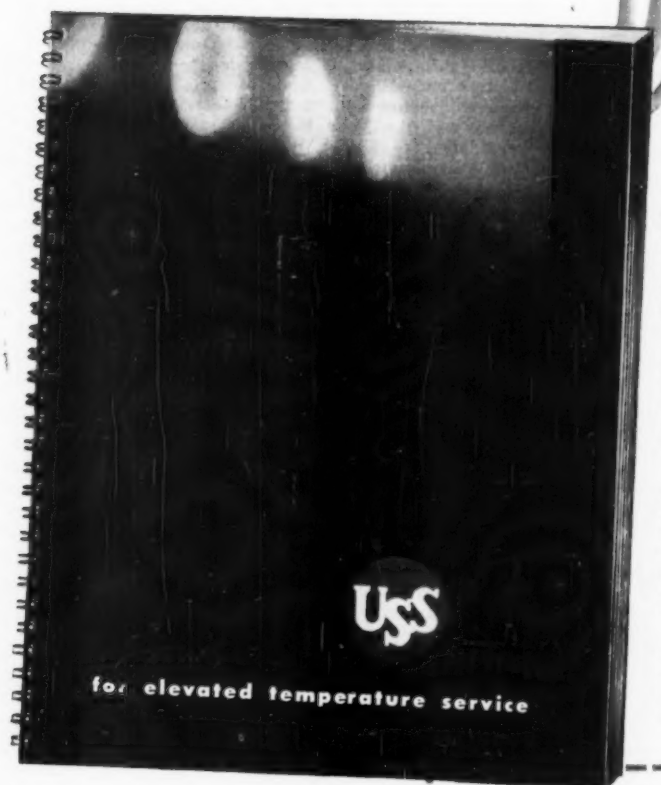

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In the comprehensive data section, the significant property values of *twenty-one* different steels, suitable for use at elevated temperatures, are presented both in tabular and graphical form. Characteristics such as high temperature strength, corrosion resistance, weldability and others are discussed.

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UNITED STATES STEEL

Hot Tinning of Fabricated Articles*

THE IMPORTANCE of the tinning of articles made of steel, cast iron, copper and bronze makes any authoritative discussion of interest. Such information is found in this recent booklet, which covers the last eight years and supplements the work of C. E. Homer published under the same title by the same sponsor in 1940.

Attention is drawn to the thickness of tin coatings by the hot tinning method, namely between 0.0003 and 0.0015 in., the average being 0.0008 in. If thinner or thicker coatings are required, other methods are suggested. A simple explanation of the tinning process is offered. The various stages of tinning are discussed, including cleaning, with vapor degreasing, hot alkali degreasing, and "burning off" in a muffle furnace. Pickling tanks for use with hydrochloric, sulphuric and nitric acids are described, as are suitable tanks for fluxing. The unsuitability of steel or iron tanks for holding flux is mentioned. The container for the tinning bath itself is described; it is either cast iron or welded mild steel. Finishing equipment is discussed in detail. The best steel for hot tinning is mild steel with carbon below 0.2%.

Steels difficult to tin are shown to be no mystery; those giving most trouble are steels heavily cold worked in the presence of lubricants and especially those subsequently annealed without removal of the lubricants.

Definite formulas are given for making up detergent solutions. The preparation of "difficult steels" for tinning is described, including mechanical treatment, heat treatment, etching and anodic pickling.

A method is given for the determination of iron in zinc chloride flux solutions.

Under the heading "Tinning of Steel" precise details are given as to procedure for both single and two-pot methods, together with illustrations. Retinning of used steel articles such as milk churns and other dairy equipment is discussed. The quality of tin is given and the contamination of tinning baths with iron. Gritty coating due to iron is also explained with illustrations.

The tinning of cast iron by the Tin Research Institute chloride and nitrate methods, the Kolene process and the wipe-tinning method are all described. The nitrate method and the Kolene process appear similar in principle. The latter has been promulgated in the United States for some years now. The principle involved in both is the oxidation of the graphitic carbon in the cast iron, thus removing it from the surface to be tinned.

It is the coating of graphite left after pickling that has been the great problem in tinning. Warning is given of the danger of letting organic matter such as sacking, wood, or grease come in contact with the fused nitrate, as the reaction is violent to the point of explosiveness. Precise details are given for wipe-tinning of large cast-iron bearings.

The method of electroplating cast iron with iron or another metal is also explained. Advice is given as to which of the several methods is best for the particular part under consideration.

The tinning of copper is discussed and attention is drawn to the fact that tough pitch copper having copper oxide as one of its constituents frequently requires special preparation before tinning.

The methods for pickling, cleaning and fluxing are carefully described, as well as the dip-tinning of copper, and wipe-tinning. Tinning of copper tubes and wire is also explained. Silicon and beryllium bronzes, if properly pickled and treated with a flux slightly more acid than normal, will tin satisfactorily.

Tinning with tin-lead alloys is also discussed, both for steel and copper.

The treatment of tinning-shop residues is discussed with methods of handling, including a recent Canadian patent for purification of molten tin by filtering through asbestos cloth.

Methods of determining the thickness and continuity of coatings are explained.

This book is essentially a practical manual, compiled to meet the needs of operative tinners, foremen and design engineers. Where theoretical discussion is deemed to assist understanding of technique, such discussion is given as simply as possible. Considerable attention is devoted to plant requirements, and useful hints on plant layout are provided. A useful bibliography is included. H. J. ROAST

*A review of "Hot Tinning", by W. E. Hoare, published by the Tin Research Institute, 1948. 112 p.

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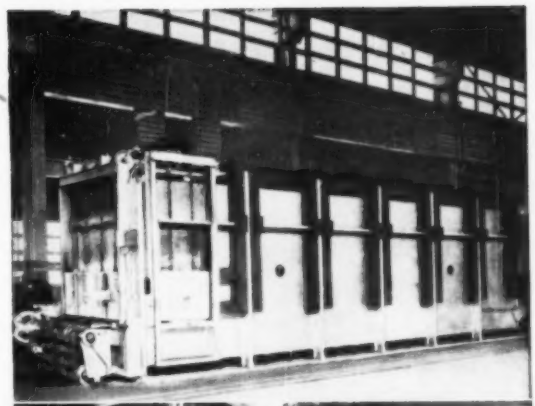

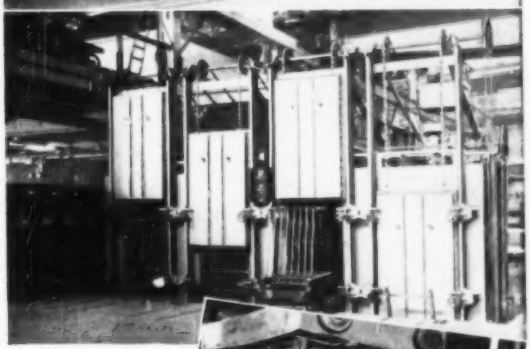

● The uppermost picture shows an EF continuous chain slat conveyor type furnace for heating aluminum billets for forging. The center view shows an EF 400 KW four chamber car type batch furnace for homogenizing magnesium cakes. The lower view shows an EF 600 KW continuous recirculating pit type furnace in which propeller blades suspended from a car are heated and quenched.

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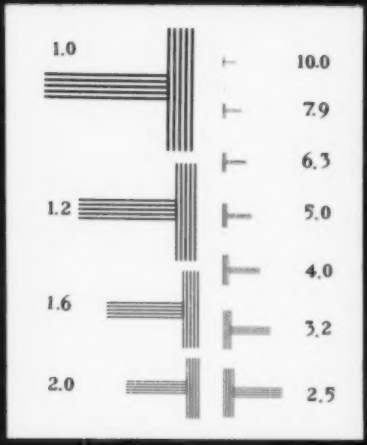
RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and 100 / 20 = 5.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and 7.9 x 5 = 39.5 lines per millimeter recorded satisfactorily. 10.0 x 5 = 50 lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.